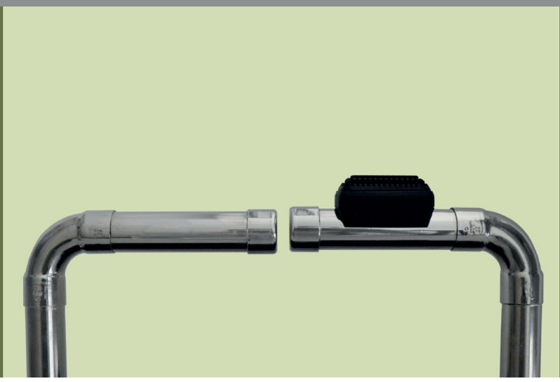
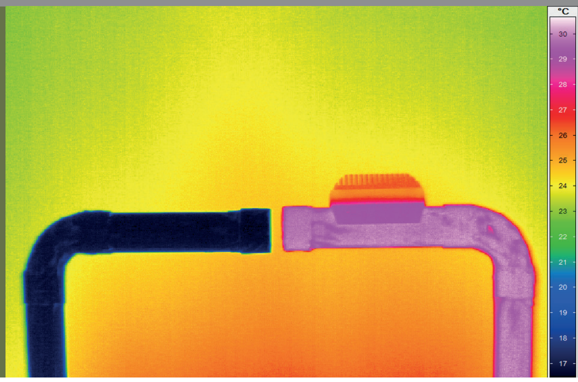
Fraunhofer IIS

FRAUNHOFER INSTITUTE FOR INTEGRATED CIRCUITS IIS





THERMAL ENERGY HARVESTING

The technology of Energy Harvesting uses ambient energy like light, heat or motion to generate electrical energy. Besides solar harvesting, thermal harvesting using heat is a very straight forward method to provide electricity. Thermoelectric generators (TEG) are employed to convert thermal differences into voltages for powering electrical devices or charging batteries.

Fraunhofer Institute for Integrated Circuits IIS

Management of the institute
Prof. Dr.-Ing. Albert Heuberger (executive)
Dr.-Ing. Bernhard Grill

Am Wolfsmantel 33
91058 Erlangen, Germany

Contact
Dr. Peter Spies
Nordostpark 84
90411 Nürnberg
Phone +49 911 58061-6363
peter.spies@iis.fraunhofer.de

www.iis.fraunhofer.de/energyharvesting

Applications

Typical application fields for thermal harvesting are motors and machines, heating and air condition systems, windows and doors or the human body. Most often wireless sensors or sensor networks are powered by thermoelectric generators. The task of these wireless sensors is always the acquisition of physical parameters in complex systems to enable a monitoring and control functionality. In more advanced applications even tracking or cellular communication systems are powered by energy harvesting. Structural health monitoring, building automation, condition monitoring, transport and logistics and the Internet of Things (IoT) are typical scenarios in today's applications. At the human body, small electronic devices like watches, medical sensors or the like can be powered with thermal harvesting. In other installations of thermal harvesting large amounts of excess heat are used to charge batteries and use it later on for powering various devices like lighting, displays or other electronic systems. Melting furnaces, steam-engines or the exhaust chain of cars are examples for locations of large scale thermal harvesting.

Challenges

The realization of an efficient thermal harvesting system faces different challenges. At first, good heat conductivity from

the heat source to the TEG and from the TEG to the heat sink and the environment has to be designed. Thermal simulations consider the properties and dimensions of the building blocks and calculate the optimum configuration for the proper heat flow. Furthermore, a good electrical matching between the TEG and the electronic power management has to be provided. Optimized voltage regulators are used for this purpose, which might also use maximum power point tracking techniques when sufficient power is available and the thermal gradient exhibits some variability. To use even smallest amounts of energy from the ambient, like in human body or building applications, ultra-low voltage up-converters can be used to work with lowest voltage levels from the TEG. Finally a highly efficient charge regulator to store the energy in an application-specific energy storage device has to be designed.

Considering the challenges above, a multi-disciplinary approach including material science, physics and electrical engineering is mandatory to arrive at a power-efficient and cost-efficient energy supply.

Services from Fraunhofer IIS

Fraunhofer IIS carries out research and development in different areas of thermal harvesting.

We offer:

- Highly-integrated voltage converters: Minimum start-up voltages below 20 mV and high efficiency up to 90 %
- Charge regulators and battery management circuits: Efficient charging of different kinds of energy storage devices with optional state-of-charge estimation
- Maximum Power Point Tracker Control loops for voltage converters to carry out automatic impedance matching
- Characterization of thermal harvesters: Lab equipment for generating defined thermal differences and measuring the output power as a function of various parameters
- Thermal modelling and simulation: Software-tools for modelling thermoelectric generators, heat-sinks and interface structure for optimization of heat flow and power output

1 Wireless sensor with thermoelectric power supply for hot or cold pipes

2 Wireless sensor with thermoelectric power supply for water management designed in collaboration between Fraunhofer IZM and IIS (www.micromole.eu)

3 Wristband with thermoelectric power supply

www.micromole.eu
microMole has received funding from *European Unions' Horizon 2020 research and innovation programme* under grant agreement No 653626.