Fraunhofer IPM

Thermopiles

Accurate, spatially resolved temperature measurements

With highly efficient semiconductor materials

Thermopiles can be used for contactless temperature measurement. Fraunhofer IPM is developing highly sensitive thermopiles based on novel thermoelectric materials in MEMS technology.

Thermopiles detect infrared emissions and are used for contactless fever measurements, for example. In technical systems, thermopile arrays are used to detect hot spots in motors or circuit breakers, ensuring a safe operation. Fraunhofer IPM is developing novel materials for thermopiles that detect temperatures more reliably and accurately than existing thermopile arrays.

Detection of temperature gradients

A thermopile is an electrical component that uses the thermoelectric Seebeck effect to convert thermal energy directly into electrical energy. A temperature-dependent voltage is generated at the junction point of two electrically conductive materials if the temperature at this point differs from the ambient temperature. When the junction point is heated by absorption of infrared emissions, the thermopile becomes a broadband radiation detector that can be used for applications such as contactless temperature measurements.

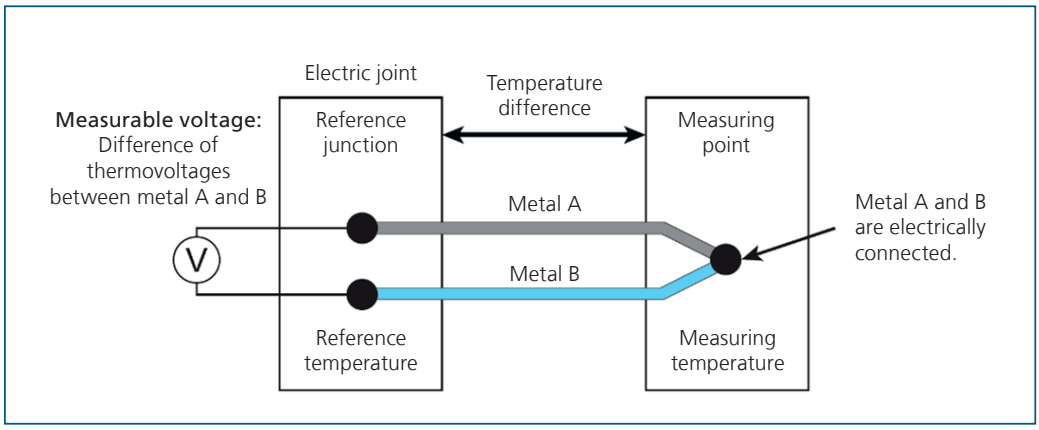
Remote fever detection requires high accuracy

Thermopiles have been used and sold commercially for about a hundred years, for example in industrial pyrometers, motion detectors and tympanic ear thermometers. Thermopile elements in which the junction point of the two metals (e. g. copper and constantan) and a thermal radiation absorbing material are mounted on a silicon membrane are state of the art. The rapid development of silicon micromechanics has made it possible to produce thermopile arrays in MEMS technology in recent years.

Our service

- Materials and deposition techniques for specific applications
- Optimized custom sensor layouts
- Manufacturing concepts
- Technology consulting

Operating principle of thermopiles



The silicon-based thermopile arrays currently available on the market are not accurate enough for remote fever detection. Fraunhofer IPM has developed thermopile arrays for spatially resolved temperature measurements that are much more sensitive than available arrays. Novel thermoelectric material combinations that can be used at room temperature allow temperatures to be measured with much higher accuracy. Semiconductor materials based on bismuth telluride alloys (Bi_2Te_3) have a higher Seebeck coefficient, achieving twice the signal amplitude for the same temperature change compared to conventional material combinations. Depending on customer requirements, this allows arrays with reduced pixel size and number to be realized without compromising the resolution.

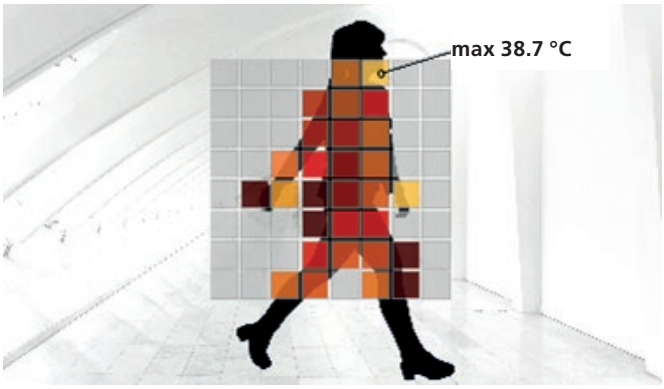
The presence of people can generally be detected with cameras and image processing, but this violates privacy rights. In such cases, the coarse resolution of thermopile arrays offers an advantage: For example, a thermopile can be used to permanently monitor the activity of the sick and elderly without invading their privacy.

Deposition technologies – customer-specific and scalable

The novel thermopile materials developed at Fraunhofer IPM can be applied on customer-specific substrates in various ways. Substrates of up to 6 inches can be proceeded in Fraunhofer IPM's cleanroom. Thermal and mechanical simulation models are used to further optimize the sensors for individual requirements. The sensors can also be manufactured directly at Fraunhofer IPM.

Tailor-made readout circuits – fast and energy efficient

In addition to highly efficient materials, an optimized electrical readout circuit of the thermopile array is critical to unlocking the full potential of the sensors. When it comes to noise reduction, speed and energy efficiency, Fraunhofer IPM has years of experience in designing electric circuits. The requirements are optimized for each measuring task.



Remote fever measurement: Layout of an eight by eight pixel thermopile array for spatially resolved temperature measurements.

Contact

Mike Benkendorf
Project Manager
Phone +49 761 8857-749
mike.benkendorf@ipm.fraunhofer.de

Fraunhofer Institute for Physical Measurement Techniques IPM
Georges-Köhler-Allee 301
79110 Freiburg, Germany
www.ipm.fraunhofer.de/en