Captec Entreprise www.captec.fr

Heat Flux Sensors

- High sensitivity
- Low thickness (0,4mm)
- Short response time
- Low thermal resistance
- Low electrical resistance
- Built in T thermocouple
- All sizes and dimensions on request
- Custom made for various special applications
- High pressure models (1OO bars)
- High temperature models (300°C)
- Cryogenic applications

ADVANTAGES

Easy to use: simply connect the terminals to a millivolt or a microvolt meter.
Custom tailored for better fit: Size and shape possibilities are unlimited. CAPTEC builds sensors as large as 300*300mm, as small as 5*5mm. You can specify specific shapes to follow the curves of your hardware. Computed aided design produces uniform or profiled heat flux sensing elements to meet your precise needs.
Integral temperature sensor: CAPTEC can furnish heat flux sensors with integral thermocouple built in the sensing area ideal for heat transfer controllers.
Heat flux sensing assembly: As an added service CAPTEC can clamp heat flux sensors to mating metal parts. Our specialised equipment guarantees superior performance.
Ultra thin and low response time: the thinner the sensor is the shorter is the time required to reach its steady state sensor temperature.
Electric resistance: lower than 500 Ohm.

Heat Flux Sensors

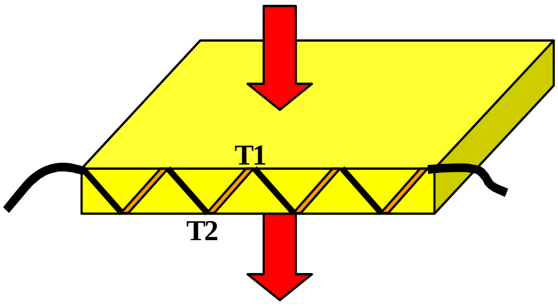
SPECIFICATIONS

Accuracy: Thickness of 0.4 mm
Sensing Area: Up to several square feet (precisely shaped and sized on request)
Operating temperature: from - 180°C to 200°C (-330F to 500F)
Thermal resistance: 0.00015°C/W/m2
Input range: - 1000 kW/ m2 to 1000 kW/ m2
Electrical resistance: About 100 ohms for a sensing area of one dm2 (0.1 ft square)

UTILISATIONS

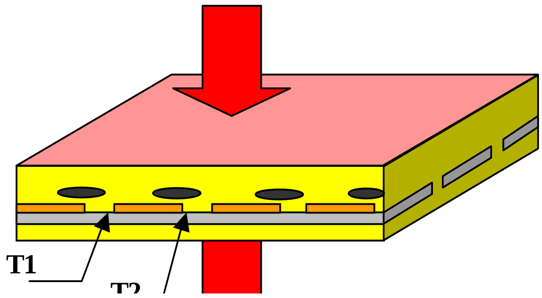
Although heat flows from hot to cold, the flow of heat across the surface of the CAPTEC sensors is measured without intermediary temperature measurement. These devices are based on sensing electrostatic charge distributed by outside thermal influences on the junctions of the planar detector incorporated in their sensing area.

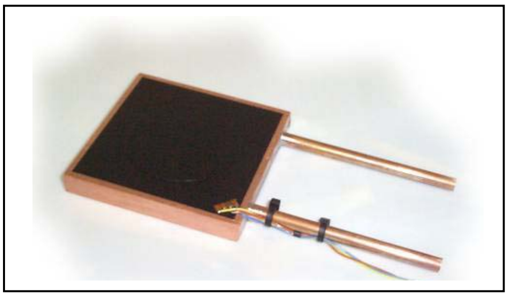
These junctions are formed by the contacts between a succession of highly conducting electrodes and their continuous metallic support of poor conductivity. They delimit on the continuous support of poor conductivity nearly isothermal and equipotential regions shielded from outside influences by electrostatic charge contained on their contour.
When heat is prevented from reaching one portion of the junction area, heat flux lines will incline on the junction area and so there must reside at the electrode ends just the proper distribution of electrostatic charges to be the source of net electric field parallel to the detector surface. Heat flux is converted into electric flux.



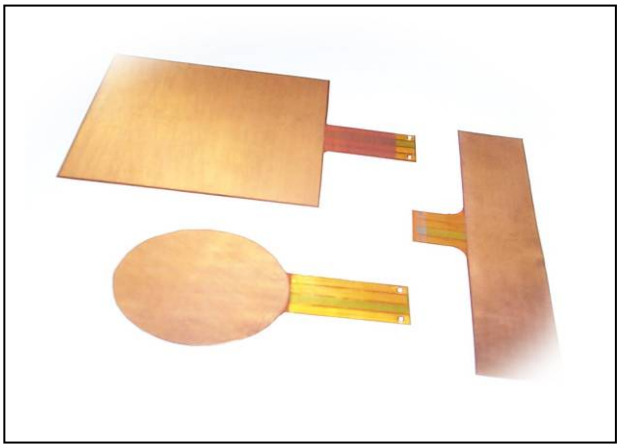
Sensing electrostatic charges distributed on the junction boundaries leads to detect heat flux as a field vector which can vary in magnitude and direction from point to point on the planar detector surface.

Heat flux is detected independently from the sensor temperature of influenced by the surface energy balance.





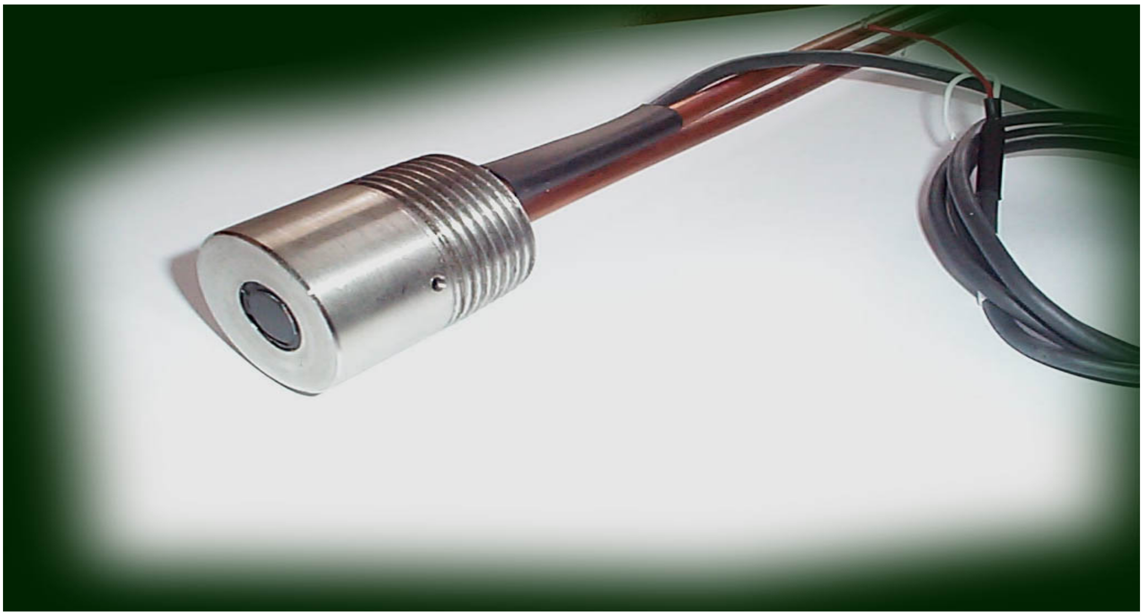
Heat flux produced by outside influences on the sensor area is determined by dividing the sensor reading by its sensitivity.
The device sensitivity is the output voltage per unit flux (of 1 W/m^2).



The sensor can be calibrated by radiation, conduction or by contact. In the calibration by contact, the sensor is mounted on the surface of a metallic support and detects heat flux produced by the thin plane heater in contact with its sensing area. The temperature gradient is negligible in the metallic support, and so the detected heat flux is produced by all the W/m^2 delivered by the heater. Sensitivity is the electric signal delivered by W/m^2.

Sensitivity to low heat fluxes (a fraction of W/m^2) is the same than sensitivity to very high heat fluxes (several hundreds of kW/m^2). Since their introduction by CAPTEC over 10 years ago, heat flux sensors have demonstrated significant advantage as compared with conventional sensors essentially because their response does not depend on the interfering changes in the sensor temperature.

Larger the sensing area, larger the sensitivity (nearly 0,5 $\mu V/W/m^2$ for each additional square cm^2 of sensor area). The important problem encountered in practice is thus to determine how large must be the sensor area for accurately measuring an expected heat flux or a minimum detectable heat flux.



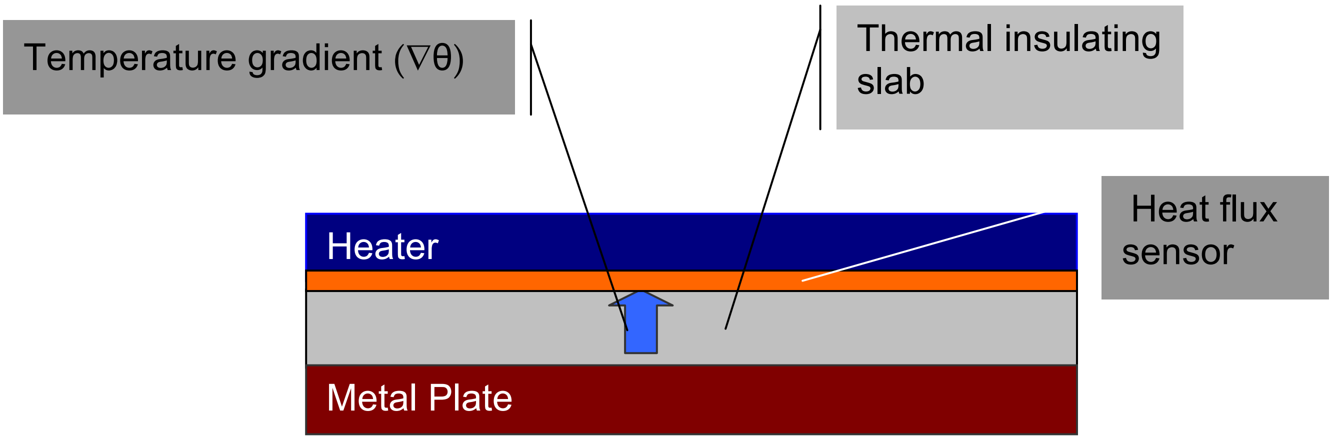
When measuring heat flux produced by the external sources, the response to the flux produced by the superposition of several outside sources or bodies at different temperature is the superposition of the responses to the flux produced by each source taken separately.

Heat flux and thermal conductivity:

Heat flux produced by the heater in the poorly conducting slab (shown in the figure below) is given by the Fourier's law ($\varphi=-\lambda\nabla\theta$) and is measured by the surface mounted heat flux sensor.

The temperature gradient $\nabla\theta$ produced by the heater across the poorly conducting slab is measured by a series association of numerous thermocouples distributed on the sensor area.

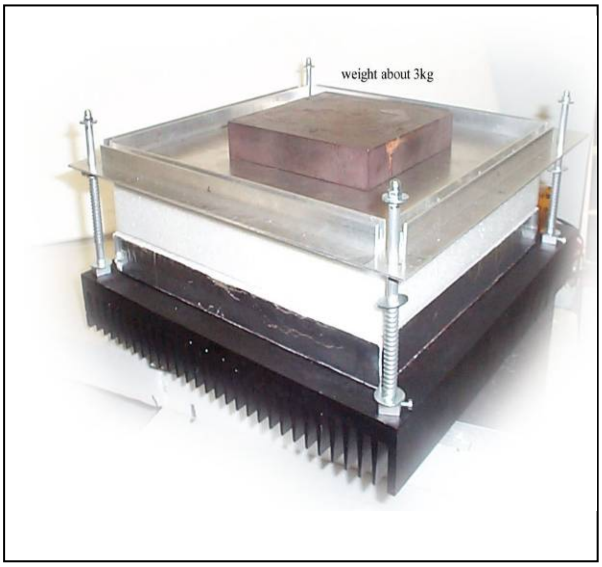
Heat flux is measured independently from the temperature gradient produced by the heater on the poorly conducting slab.



Thermal conductivity is defined to be heat flux ($\varphi = -\lambda\nabla\theta$) per unit temperature gradient ($\nabla\theta = \Delta T/e$) ; Thermal conductivity is determined by simultaneously measuring heat flux in W/m^2 and temperature gradient in °/m produced by the heater on the poorly conducting slab.

Thermal conductivity tester

Heat flux across the sample to be tested (with shiny edges on the figure) is generated by electric power dissipated in the thin electric heater in contact with the top side of the sample and finally dissipated in the bottom metallic plate. Heat flux ($\varphi = -\lambda\nabla\theta$) in the sample in form of plate to be tested is measured by the two heat flux sensors inserted in contact with the external sides of the sample. The temperature difference across the insulating sample is about 10°C. The sample thickness is about 1/10 of lateral dimensions. Thermal conductivity λ is known when heat flux φ and temperature gradient $\Delta T / e$ are measured.

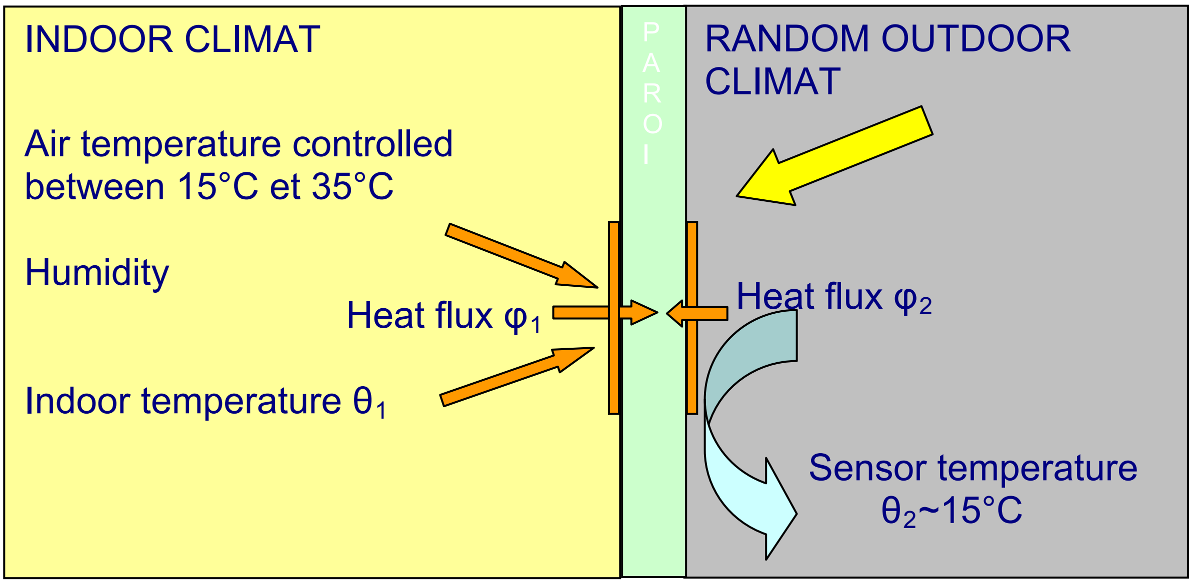


When using calibrated heat flux sensors, thermal insulating materials can be tested without reference samples. High accurate measurement (better than 3%) are obtained on samples of small conductivity λ<5W/m°C

Calibration by conduction

If thermal conductivityλ of the poorly conducting slab is known heat flux in the poorly conducting slab is known when temperature gradient$\nabla\theta$ is measured. heat flux in the reference thermal insulating sample can be determined. Because the sensor response is proportional to heat flux $\varphi = -\lambda\nabla\theta$ across the thermal insulating sample, sensitivity (delivered voltage by unit heat flux) is thus determined by dividing the sensor response in µV by heat flux across the sample of known thermal conductivity.

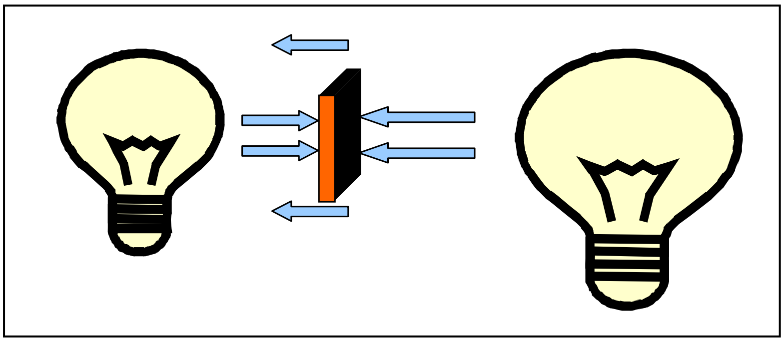
In situ measurement:



Heat flux in the wall is given by Fourier law ($\varphi=-\lambda\nabla\theta$) ; heat flux is produced by the unbalance between the heat sources (of radiation or of air motion) contained in the surrounding ambiences.
The temperature gradient $\nabla\theta$ produced by the unbalance between the heat sources across the wall is detected by a traditional thermocouple.

The thermal insulation (equal to average heat flux per unit average temperature difference) can be determined from the simultaneous measurement of heat flux in W/m^2 and temperature gradient in °/m

Heat flux measurement in gaseous media



The sensors mounted on the external sides of the metallic plate ate kept at the same temperature and are capable of sensing the heat fluxes produced by the lamps contained in the surrounding vacuum (or gaseous medium). If the differential association of sensors is suspended between the lamps at different temperature, its response will be proportional to the difference between the fourth power of the absolute temperatures (σ (T^4_2 - T^4_1)) and independent from the sensor temperature which can be continuously changing (under the influence of radiation absorption on the sensor area or of energy loss in the ambient air). Heat fluxes produced by the lamps is detected without intermediary temperature measurement.

The heat radiation unit

- Ideal for sensing the heat emission from a flare in its environment (in the range (0-4 kW/m^2)).
- Independently from the sensor temperature which can be continuously changing.
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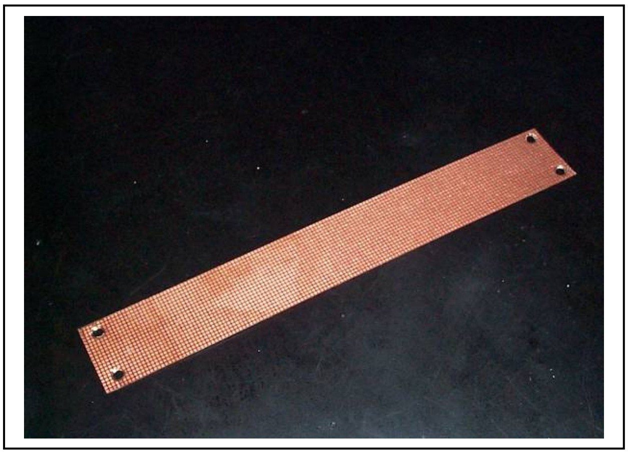
- Linear
- Sensing area:150x150mm
- Sensitivity 100mV/kW/m2
- Without glass dome
- Readout on any mV indicator

Comparing the heat fluxes produced by outside influences leads to measure asymmetric radiation between warm or cold panels, cold windows ….

Flexible heat flux sensors

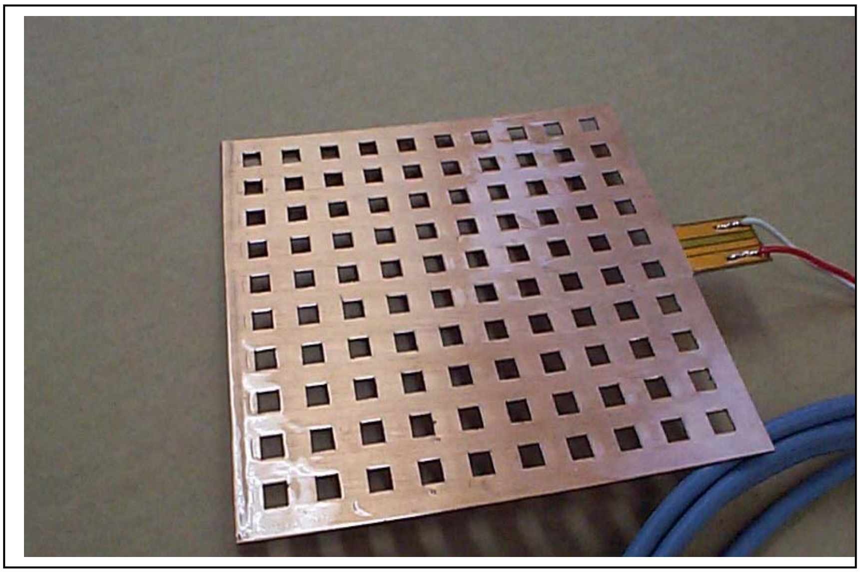


Heat flux measured by the sensor mounted on the reactor surface shown in the figure is produced by the sources of heat contained in the reactor (chemical reactions, moving fluids or heater).

The temperature rise of the reactor above its environment depends on the amounts of heat transferred from the reactor into the environment.
Calibrating the reactor sensor consists to detect the response to a known source of heat immersed in the reactor (electric power dissipated in the miniaturized heater immersed in the reactor). When calibrated, the device is capable of sensing the W/m^2 heat flux produced by the sources of heat contained in the reactor

Perforated heat flux sensor

For sensing heat flux in presence of combined fluid flow

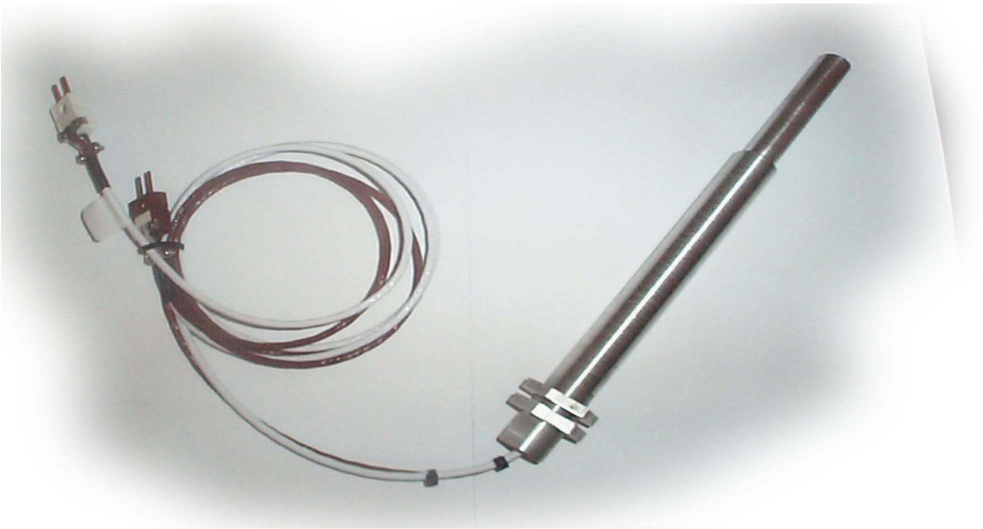


The market demand in devices capable of sensing heat flow between bodies at different temperature in solid, liquid or gaseous media is growing more and more for the development of energy related applications. CAPTEC heat flux sensors are designed for that purpose.

They are thus suitable for testing wall insulation and air conditioning control processes, reactions and phase changes in chemical industry, cloth insulation, frost detection in food industry, concrete setting.

Heat Flux Sensors

For sensing heat flux in the wall of a plastic mould



For sensing heat flux emitted from a flame