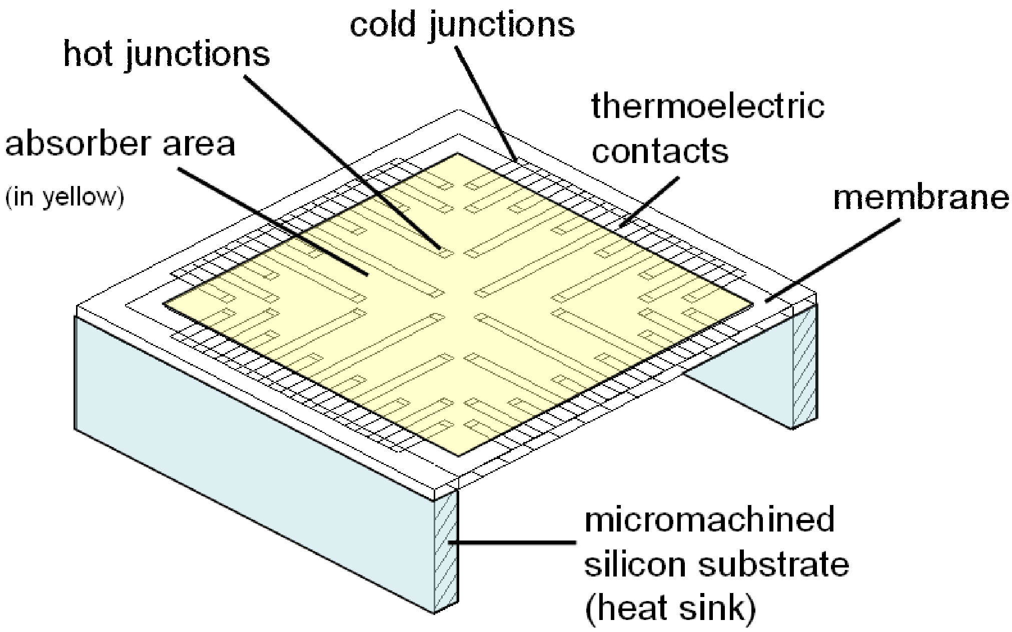
1. Thermopile chip construction



2. Thermoelectric voltage

For the thermoelectric materials we choose a combination of n-poly silicon and p–poly silicon which exhibit thermoelectric coefficients of opposite polarity. Typical values for the Seebeck coefficient range between 100 and 500 µV/K, depending on the dopant concentration. Based on this material selection we are able to fabricate the sensor in a modified CMOS process.

The sensitive element of the sensor absorbs the incoming radiation power and that leads to a temperature difference $T_1 - T_0$. For a sensor with n thermocouples the following equation is valid.

$$U_S = n\,(\alpha_A - \alpha_B) \times (T_1 - T_0)$$

U_S … thermoelectric voltage
n … quantity of thermocouples
α_A … Seebeck coefficient of thermoelectric material A (n-poly silicon)
α_B … Seebeck coefficient of thermoelectric material B (p-poly silicon)
T_1 … Temperature on hot junctions on membrane
T_0 … Temperature on cold junctions on heat sink (silicon rim)

3. Sensitivity

The voltage sensitivity S_V represents the ratio of output signal voltage U_S to incident radiation flux Φ absorbed by the sensitive area after passing the infrared window.

$$S_V = U_S / \Phi$$

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4. Noise equivalent power and noise voltage

The ratio of noise voltage U_N and voltage sensitivity S_V is called noise equivalent power or short NEP.

$$NEP = U_N / S_V$$

U_N … thermopile rms noise voltage

The thermopile rms noise voltage U_N is dominated by the thermal noise of the thermopile resistance R.

$$U_N = \sqrt{4 \cdot k \cdot T \cdot R}$$

k … Boltzmann constant
T … absolute temperature
R … Thermopile resistance

5. Detectivity

The specific detectivity D* serves to compare the performance of different types of IR sensors with different sensitive areas A.

$$D^* = \frac{\sqrt{A} \cdot S_V}{U_N} = \frac{\sqrt{A}}{NEP}$$

6. Time constant

Another important parameter is the time constant τ, which describes the response time of the thermopile output after a sudden step of irradiation. The time constant is determined by the thermal capacity H of the sensing area (membrane including absorbing area) and the thermal conductance G between sensing area and its surroundings.

$$\tau = H / G$$