Vacuum Measurement

Pirani without Zero Pressure

The 5th ITG International Vacuum Electronic Workshop 2016

Dipl.-Ing. Heinz Plöchinger

CEO

Thyracont Vacuum Instruments, Passau, Germany

Thermal conductivity measurement with "free floating" molecule detector

>“Zero-pressure” elimination with Pirani principle for vacuum measurement,

>increase of the measurement range limit of thermal gas-sensors and flow sensors

Measurement of pressure in the medium vacuum range have been done via thermal conductivity. The Pirani principle has a lower range limit - the so-called " zero pressure " - until now (1).
The minimum power needed to hold a sensor up to operating temperature exceeds the useful signal, due to the heat loss through the suspension.

The authors were able to eliminate the “zero pressure“, thereby expanding the measurement range of Pirani sensors significantly downwards .
Also with other sensors that use thermal conductivity and heat - entrainment effects, e.g. gas sensors and sensors for flow measurement , the new principle can be applied and thus lower the lower range limit.

Technical Background

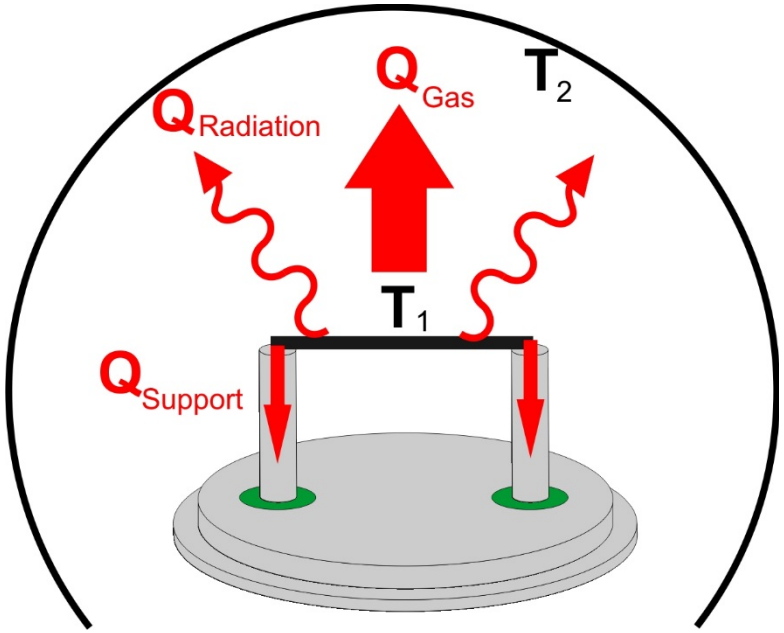
Thermal conductivity measuring elements:

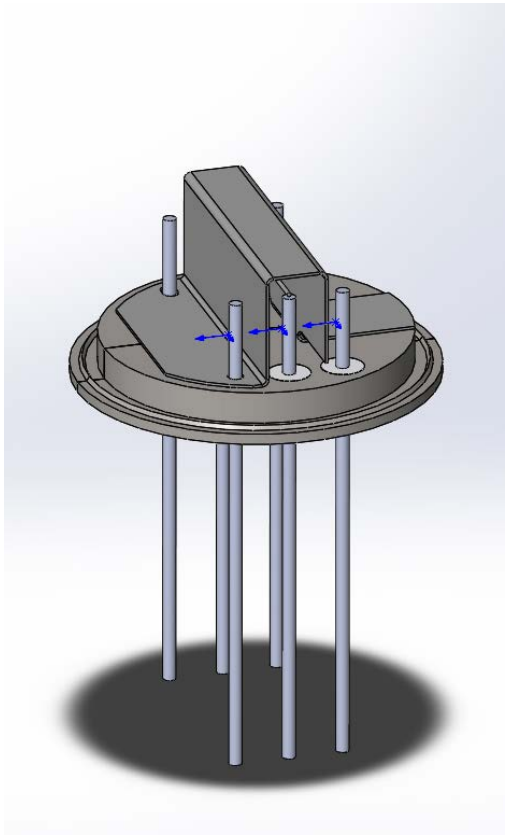
A thin metal wire with a defined temperature-dependence

of its electrical resistance is mounted on insulated pins.

Measurement of thermal conductivity (Pirani)

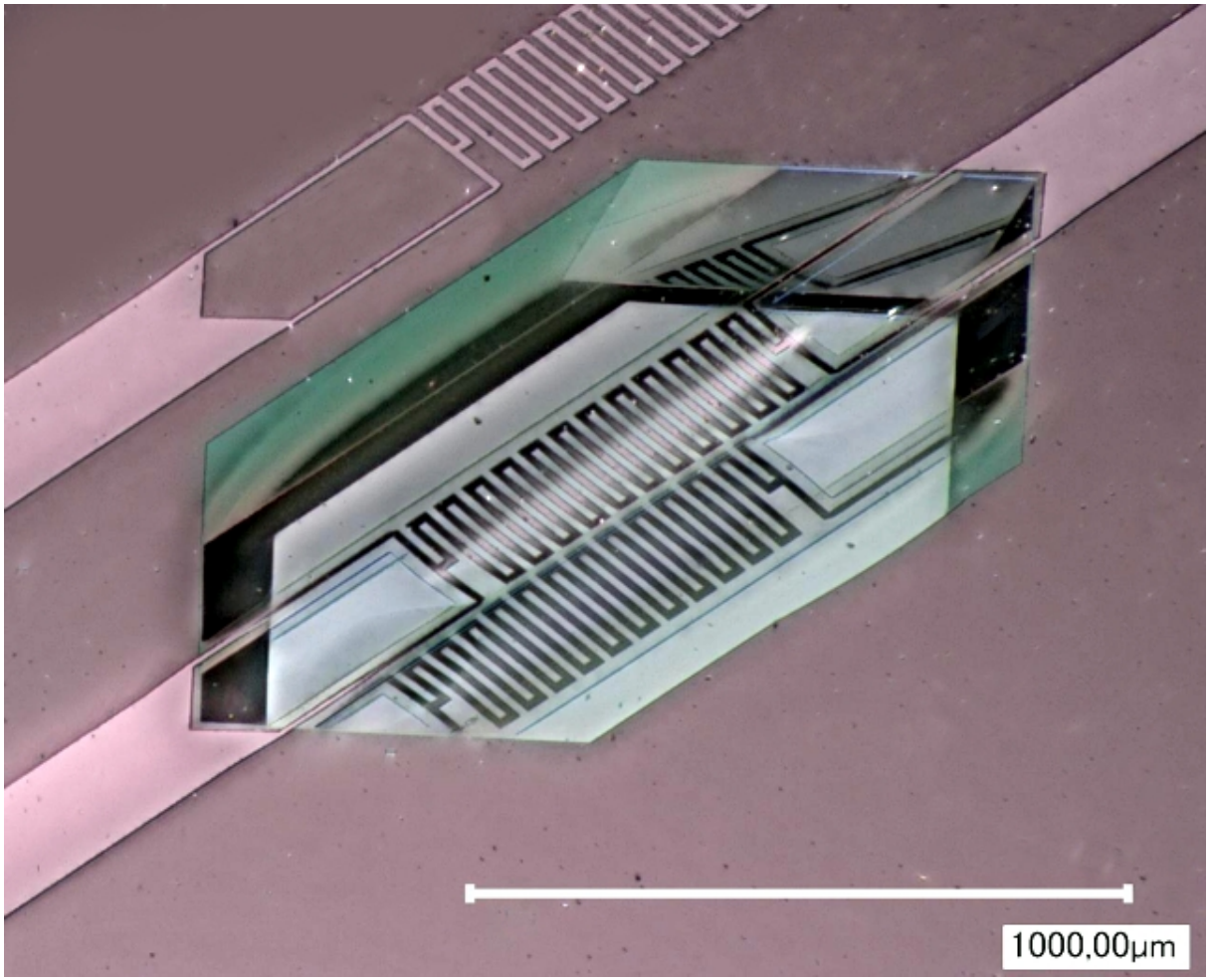
Indirect, gas type dependent measurement of pressure through thermal conductivity of the gas





Microfabricated sensors (Micro Pirani)
have planar meander instead of the wire and are mounted on oxide membranes.

Micro Pirani

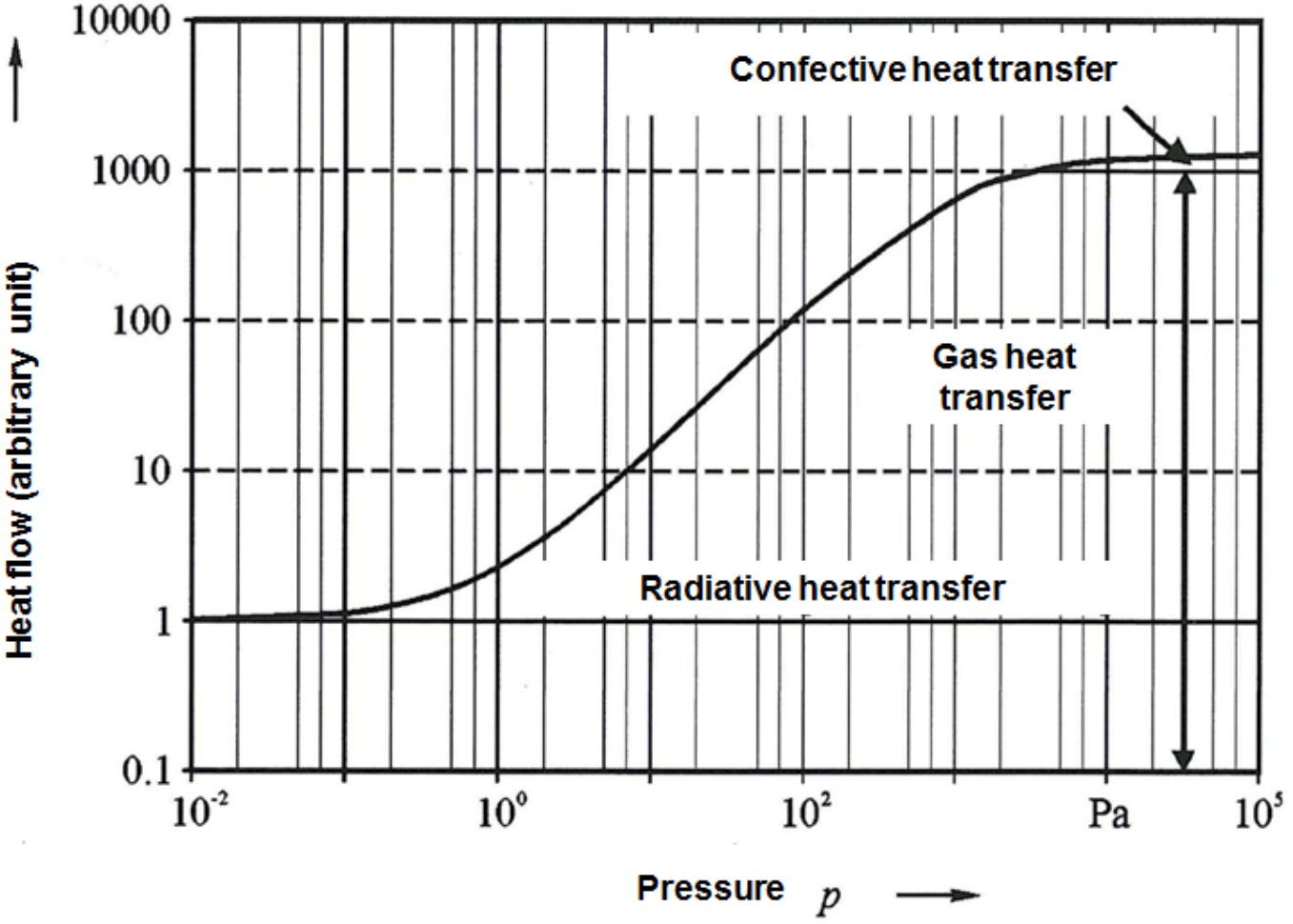


Such thermal conductivity measuring elements are immersed in the sample gas in the measuring chamber.

Most of these measuring elements are heated to a constant temperature and controlled by the flow of electricity.

The electric power supplied to this usually presents a threshold for either the absolute pressure of the measurement gas, for the type of gas or the gas flow speed.

Pirani - characteristic curve



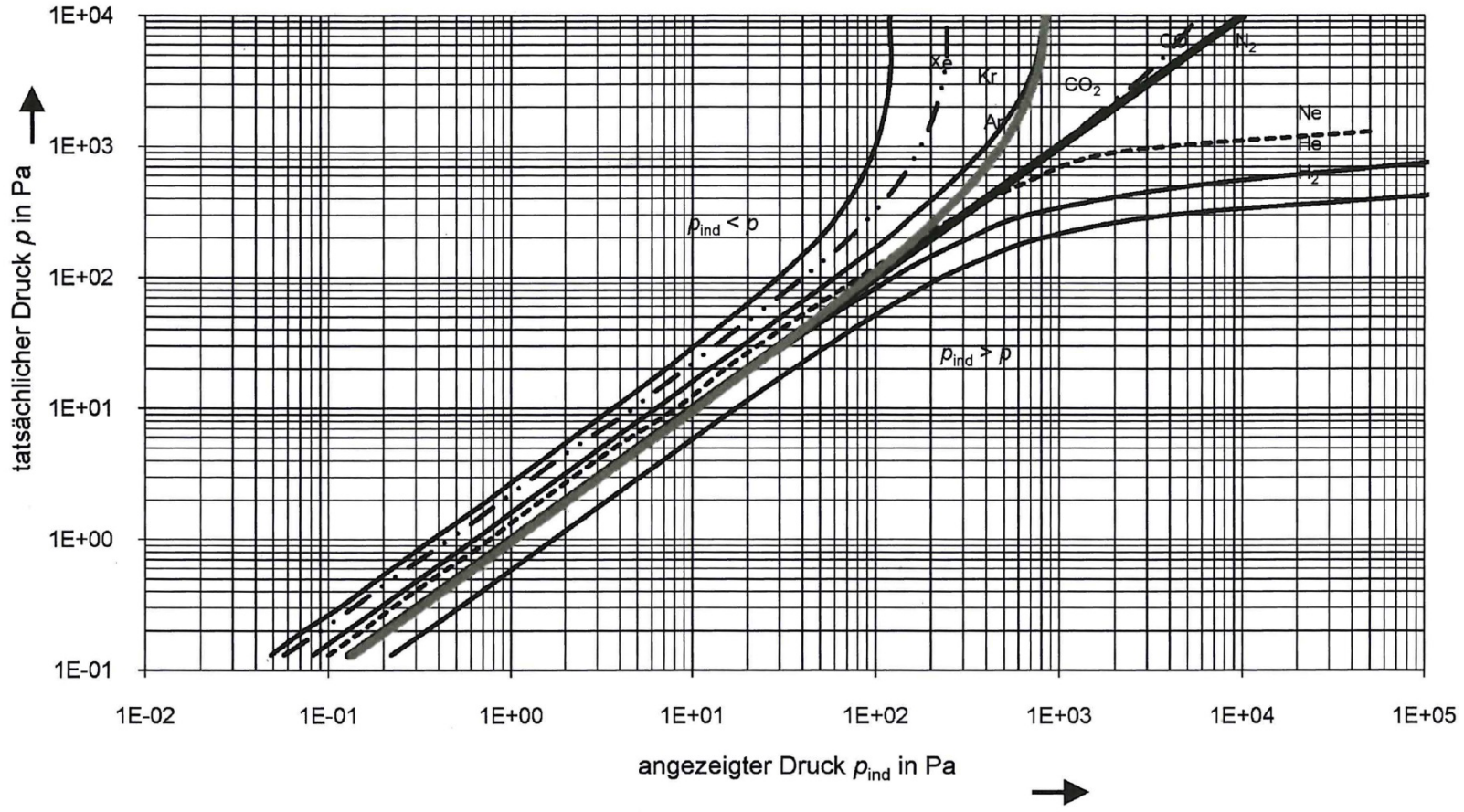
[1]

The electrical heating energy required is determined by the thermal losses in the measuring element.

The dissipated power in the Pirani sensor is composed of losses via heat conduction of the gas, the derivation via contact pins or the suspension, and the heat radiation losses

The correlation depends on the molar mass of the sample gas.

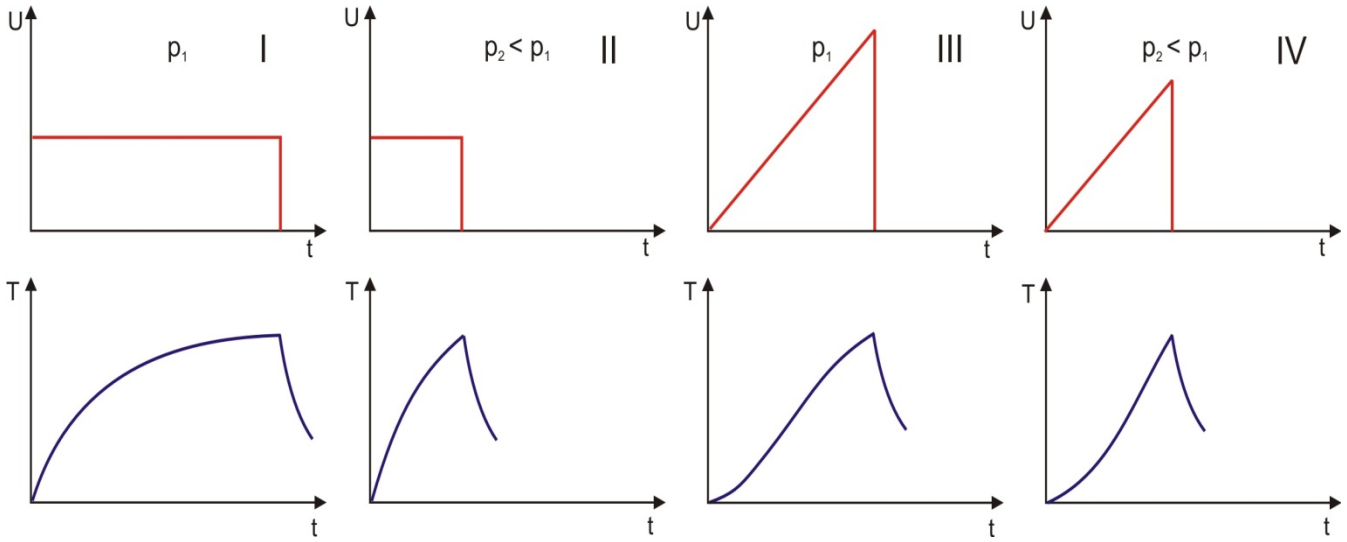
Pirani - gas type dependence



A device with a “Pulsed Pirani Sensor” (2)
presents heat capacity of the sample gas
added as a further parameter.

In principle, the ramp pulse method is also suitable
for the detection of other parameters
related to thermal conductivity or heat capacity,
for example for gas analysis.

Messprinzip Puls-Pirani



- Hoher Druck, lange Pulsdauer ←→ Messrate
- Niedriger Druck, kurze Pulsdauer ←→ Auflösung

Reduced power input

and a better resolution

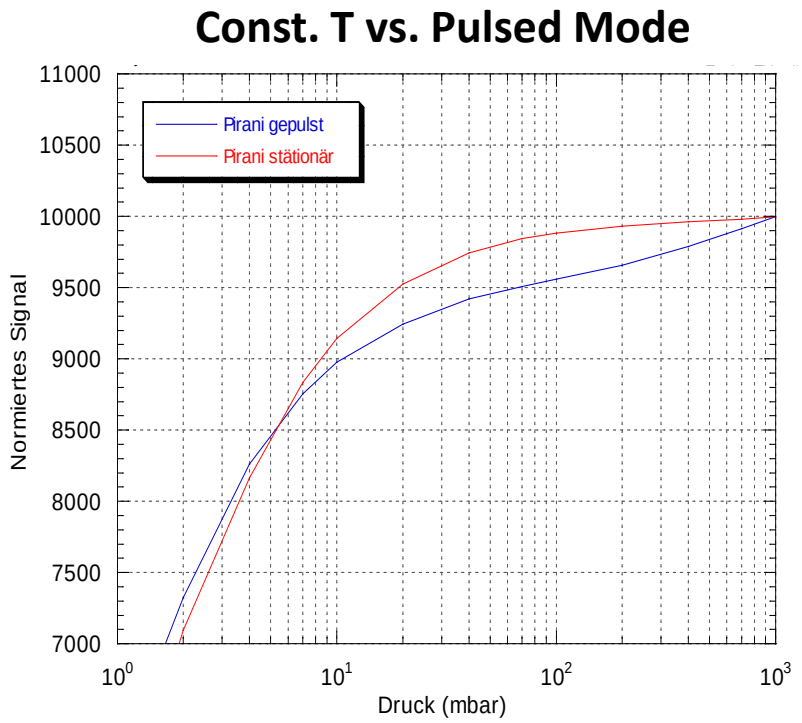
in the rough vacuum range (4)

were amongst the reasons

for the successful introduction

of this procedure.

Pulsed Pirani measurement principle



Puls-Messverfahren nutzt auch die Wärmekapazität des Gases

Zusätzliche Auflösung im Druckbereich > 100 hPa

The analytics industry needs "minimally invasive" sensors for high vacuum range.

The requirements resulted in considerations to investigate the detour via heat conduction also in this range.

Innovation „Active Suspension“ (Pat. pend.):

Even in a high vacuum, the principle applies that the heat conduction through the gas depends on the gas pressure.

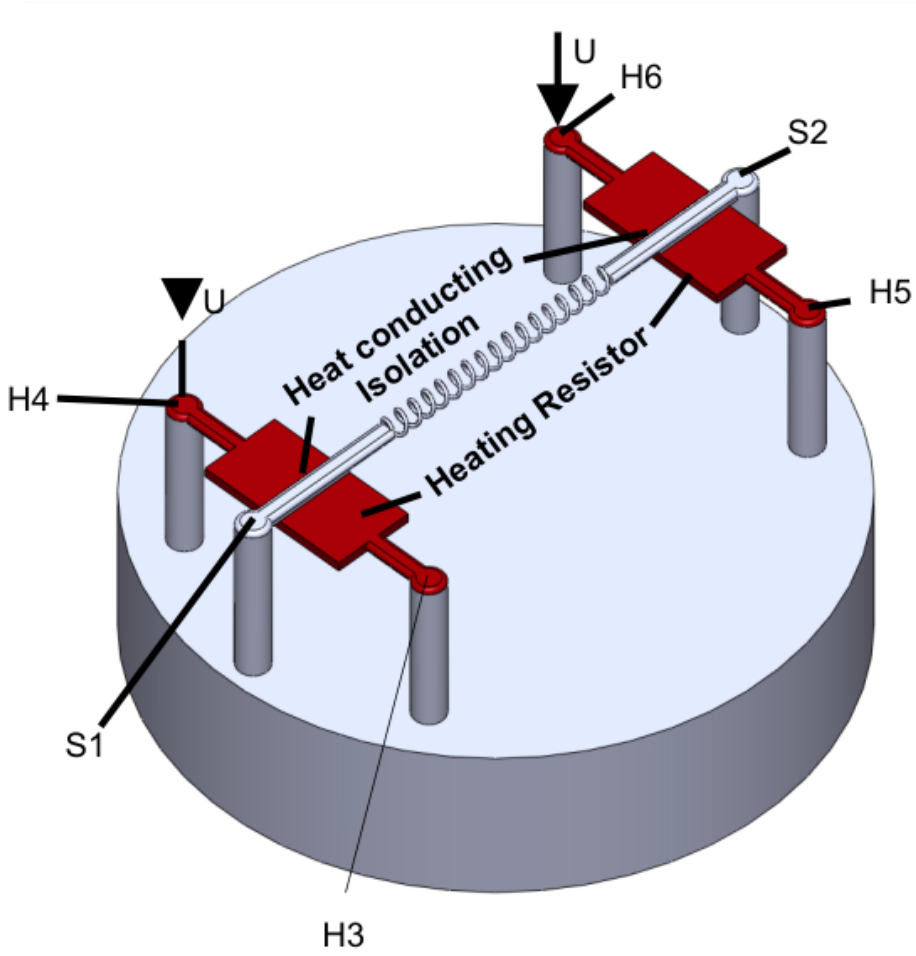
Heat loss through the suspension is compensated by supplying appropriate heating power via separate connectors H3-H4 and H5-H6.

Thus, the actual measuring element is decoupled from the basic power and thus correspondingly more sensitive to themeasuring task.

The measuring signal at S1-S2 is exempt from the offset.

It can be smoothly detected and amplified accordingly.

Pirani with separate feed of basic power

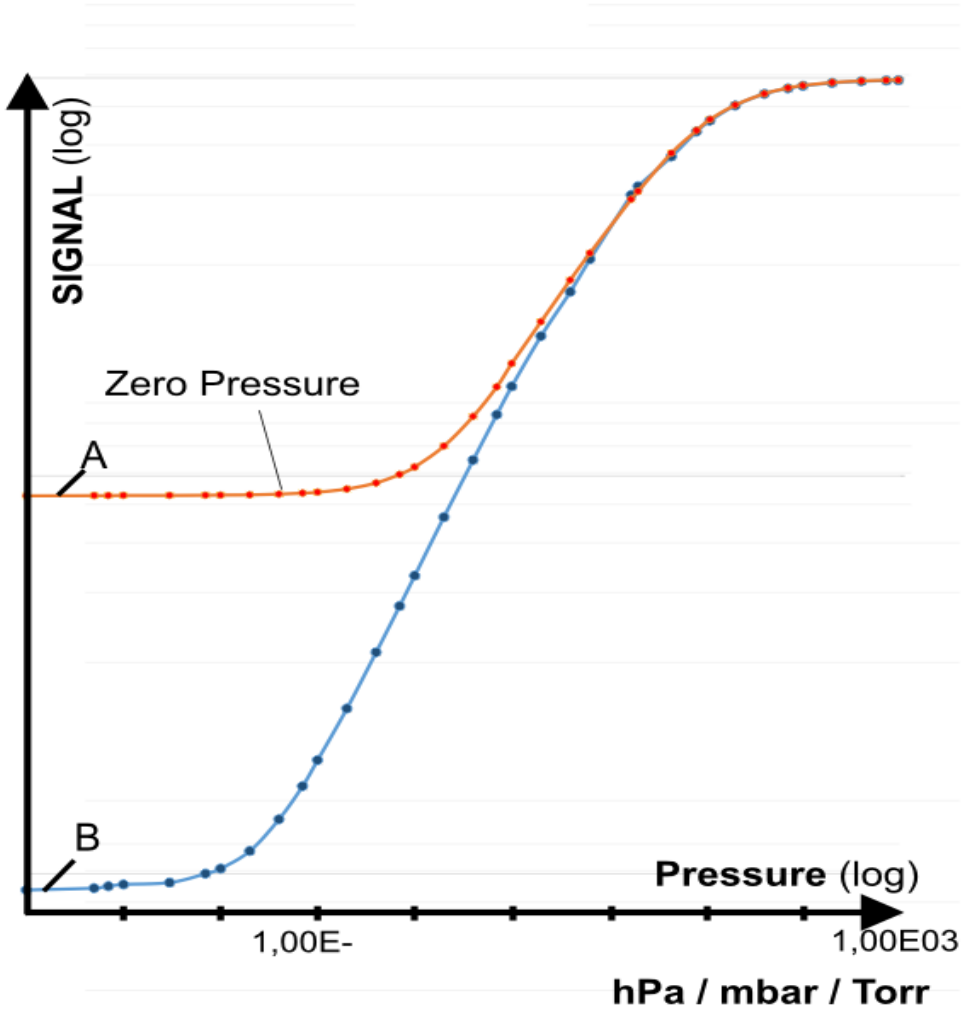


In practice, this means an extension of the measuring range down towards high vacuum

(Curve B).

(Curve A) shows the same measuring element with offset zero pressure.

Pirani – characteristic curve, Curve A with offset zero pressure, Curve B with separate feed of basic power



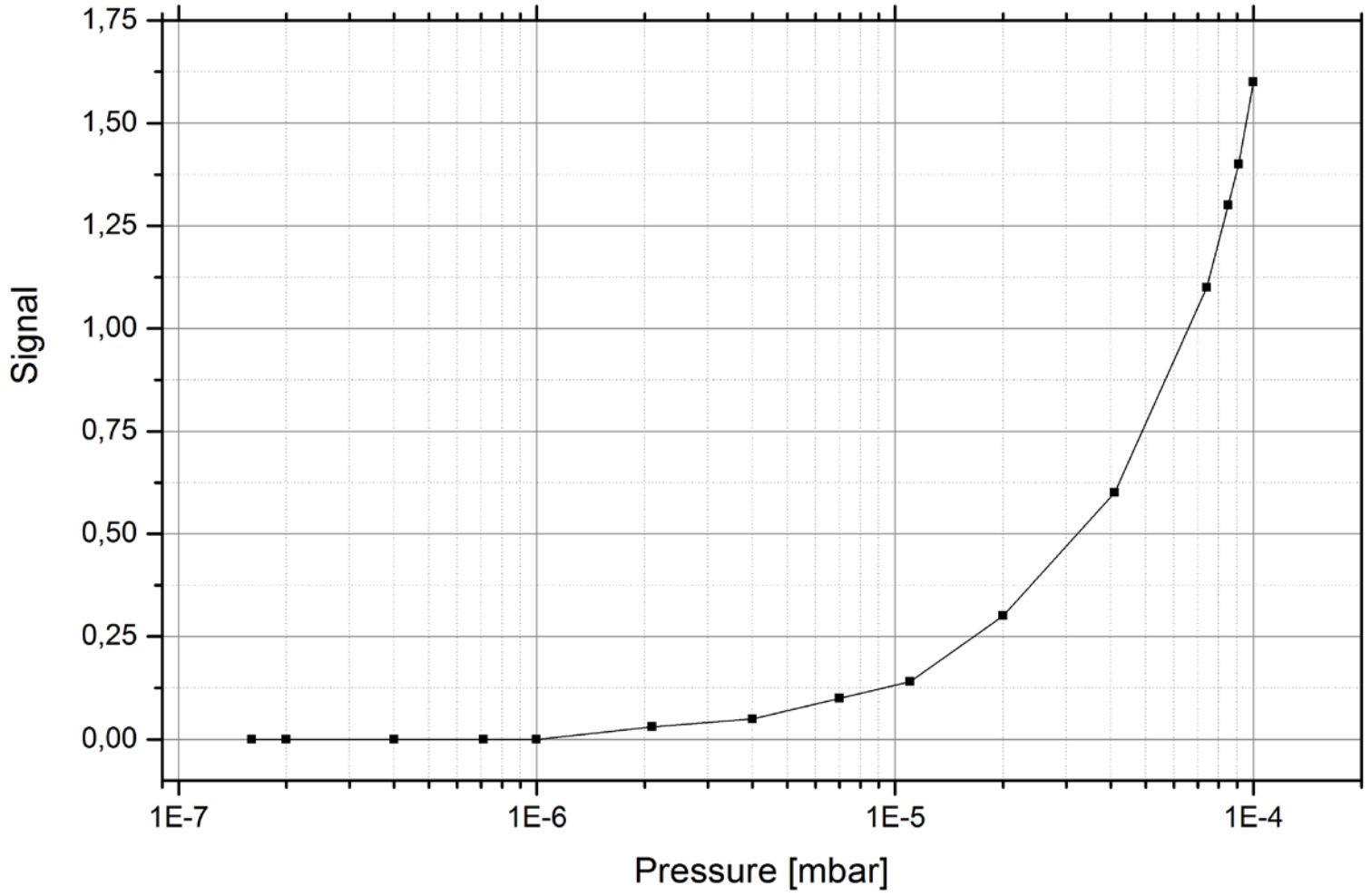
In the case of the vacuum-measurement, it is appropriate to limit the exposure to radiation losses to a small, constant factor.
This is achieved by selection of materials with a low degree of Radiation exchange “E”, the choice of a low temperature on the Measuring element and, optionally, by controlling the temperature of the exchange surface.

A first prototype of a microsystem Pirani sensor

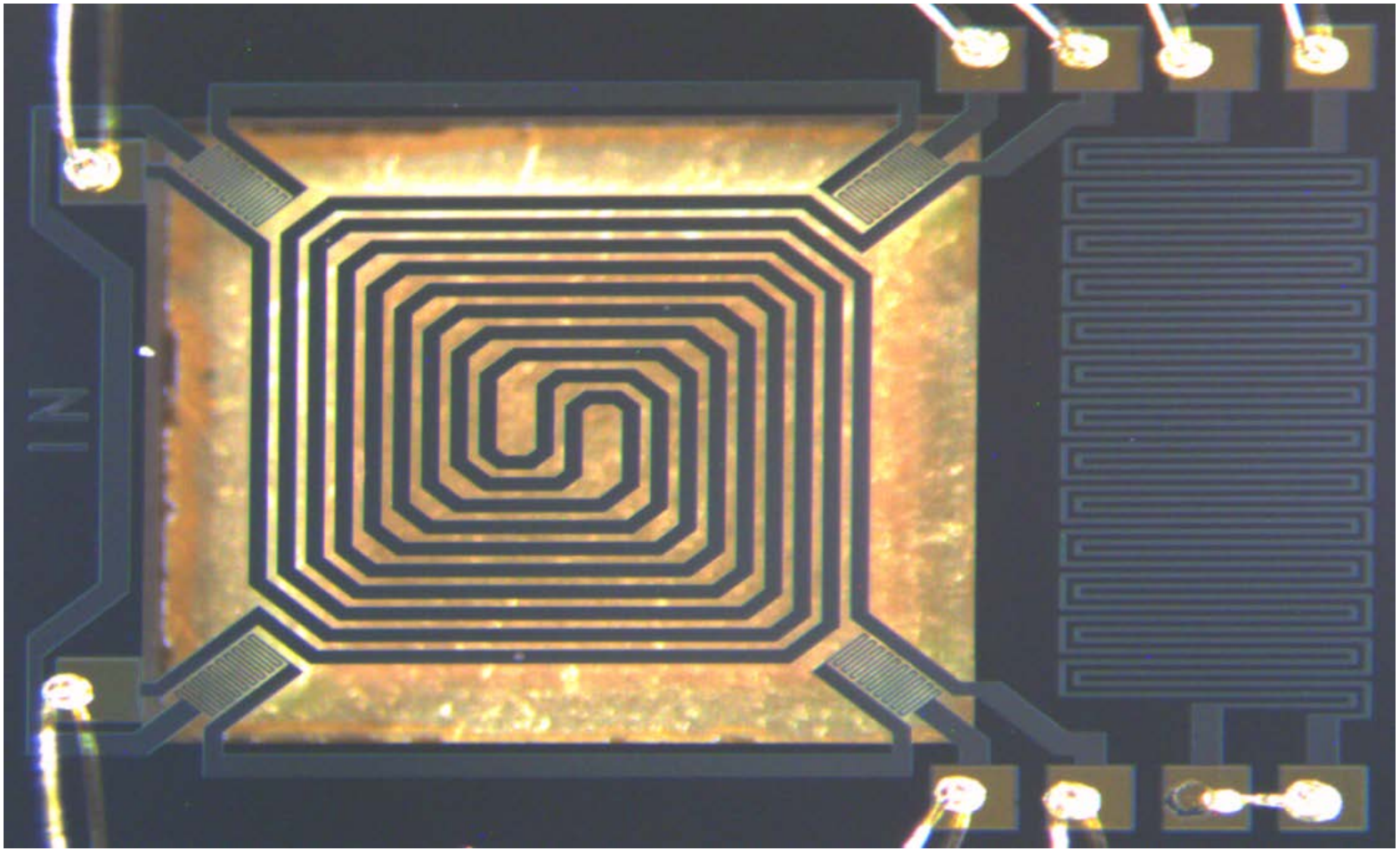
without zero pressure has already been implemented.

Other versions will be developed after redesign and extensive test series.

Pirani sensor (coiled filament PtRh) without zero pressure, filament and filament support at same constant temperature



Pirani chip with separate feed of basic power



Thank you for your attention!