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KPY 12 - A PRESSURE TRANSDUCER SUITABLE FOR LOW TEMPERATURE USE

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Résumé: Le capteur de pression KPY 12 commercialisé par Siemens permet de mesurer des différences de pression jusqu'à 2 bars dans la plage de température de 243 K à 298 K.

A des températures très basses atteignant 4 K, la linéarité est conservée et la sensibilité s'accroît de 100 % environ. Le capteur a été utilisé avec succès à basse température dans une installation d'essai fonctionnant à 3000 tr/min.

Abstract: The commercially available Siemens pressure sensor KPY 12 in silicon planar technology measures differential pressures up to 2 bar in the temperature range from 243 K to 398 K. However, at temperatures down to 4 K the specified linearity is also preserved, and the sensitivity increases by about 100 %. The sensor has been successfully employed at low temperatures in a test rig rotating at 3000 rpm.

Description of the KPY 12

The pressure deflects a silicon plate, setting up strains in silicon resistors located on top of the plate. The strains are converted into an electrical signal by the piezoresistive effect.

As is usual with strain gages, four resistors are arranged in a Wheatstone bridge. The pressure load causes a decrease in the resistance of two resistors and an increase in the resistance of the other two resistors. The chip of the KPY 12 is shown in Figure 1. It is mounted in a TO-8-like encapsulation (Figure 2). The specifications of the KPY 12 are summarized in Table 1.

Table 1:

Specifications of KPY12-pressure transducer

Operating temperature	-30 to 125	°C
Bridge resistance	≈ 7	kΩ
Full scale output	10 ± 3	mV/V bar
Zero balance	± 5	mV/V
Linearity 1)	± 0.5	% FS
Thermal sensitivity shift	± 0.2	typ. %/K
Thermal zero shift	± 0.02	%/K FS
Hysteresis	≤ 0.5	% FS
Response time	< 1	ms
Weight	≈ 2.7	g

1) maximum deviation from best straight line fit vs full scale output.

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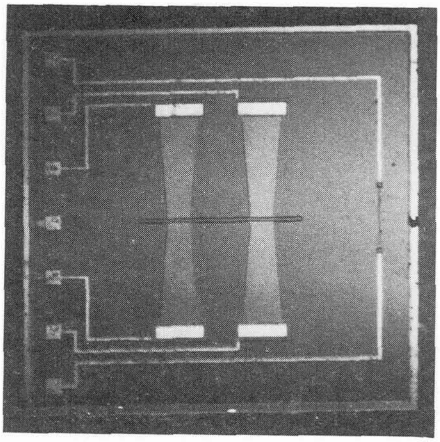

Fig. 1:

Pressure sensor
chip-size 4 x 4 mm²

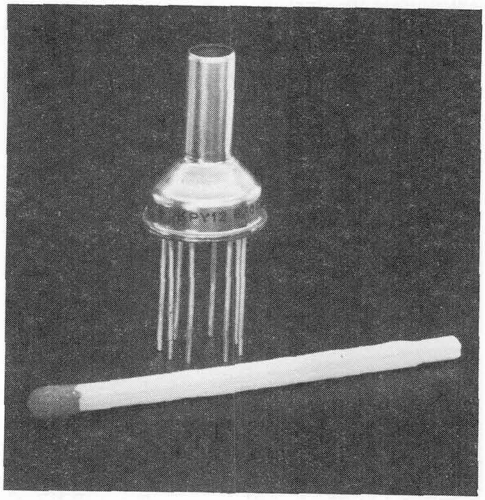

Fig. 2:

KPY12 sensor

Low temperature experiments

The bridge voltage, U, and the supply current, I_s, of several sensors were measured as a function of pressure, p, and temperature, T. The supply voltage was U_s = 5 V.

Fig. 3 shows some transducer characteristics of one sensor. At all temperatures, the linearity is as good as specified at room temperature. The sensitivity $s = (U-U_o)/p$ increases with decreasing temperature.

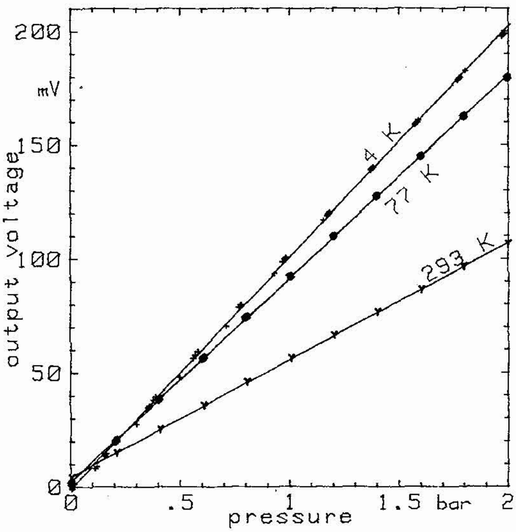

Fig. 3:

Typical output voltage versus pressure for a KPY 12 sensor at different temperatures

All sensors investigated exhibited an almost identical sensitivity increase. Compared to the sensitivity at 293 K, the increase ranged from 74 % to 77 % at 77 K and from 91 % to 97 % at 4.2 K.

The offset voltage, U_o, is sensor-specific and depends slightly on temperature. In Fig. 4, the normalized sensitivity s(T)/s(T=293 K) and the offset voltage $U_{o(T)}$ of a sensor are plotted against temperature.

Due to the specified tolerances the individual sensor has to be calibrated for a precise pressure measurement. In addition, the operating temperature must be known. For reduced precision requirements interpolation based on three reference measurements at 4 K, 77 K and room temperature may be sufficient.

At temperatures below 90 K and above 220 K the temperature can be determined from the bridge resistance $R_{br} = U_s/I_s$. It is almost independent of pressure ($d(\Delta R/R)/dp \leq 6 \cdot 10^{-3}$ bar^{-1}) but it depends on temperature. Fig. 5 shows the ratio $R_{br(T)}/R_{br(T = 293\ K)}$ against temperature. The temperature dependence was almost identical for the sensors investigated.

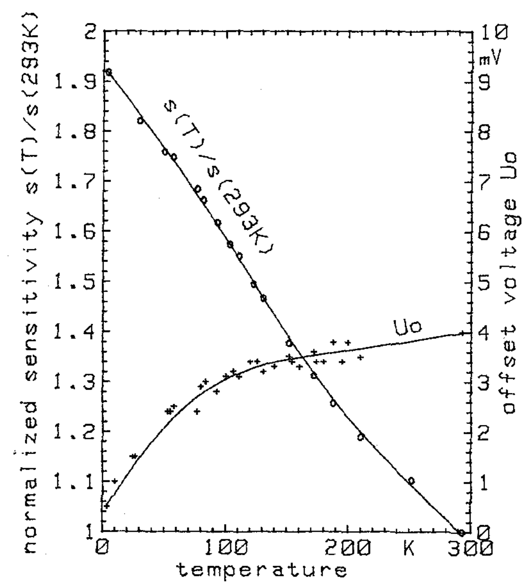

Fig. 4:

Normalized sensitivity and offset voltage against temperature

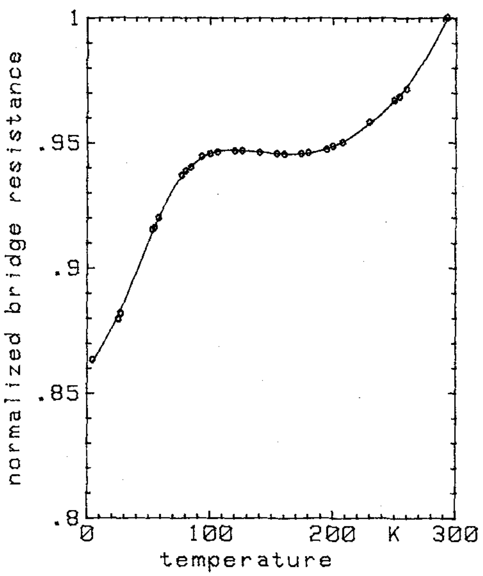

Fig. 5:

Normalized bridge resistance against temperature

Application

For testing a cooling system, the pressure of cold helium gas has to be measured directly in a container rotating at 3000 rpm. The sensor KPY 12 was chosen, because it is small, high-vacuum tight, withstands high mechanical loads and has little thermal load (typically 5 mW at U_s = 5 V). For more than one year the sensor has worked reliably and without problems.

Sensors of this type offer the possibility of measuring not only the pressure, but also derived quantities, e.g. flow rates (by measuring orifices) or liquid levels at cryogenic temperatures.

Acknowledgement

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