HIGH-PRESSURE GAUGES WITH ELECTRIC SENSORS

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Basic Parameters of a Secondary High-pressure Sensor

If $\varkappa$ is the given physical property, the basic parameters of the secondary high-pressure sensor are [1]:

$\alpha_\varkappa = [\partial\varkappa/(\varkappa_0\,\partial P)]_T$ - pressure sensitivity coefficient;

$\beta_\varkappa = [\partial\varkappa/(\varkappa_0\,\partial T)]_P$ - temperature sensitivity coefficient;

$\gamma_\varkappa = \beta_\varkappa/\alpha_\varkappa = (\partial P/\partial T)_\varkappa$ - temperature coefficient of the pressure reading shift;

$z_\varkappa = \alpha_\varkappa/\gamma_\varkappa = \alpha_\varkappa^2/\beta_\varkappa$ - coefficient of pressure quality.

The last coefficient, introduced by Czaputowicz [2] seems to be the best indicator of the suitability of a given physical property of a sensor for high-pressure measurements. It is important that the absolute value of the coefficient of pressure quality $|z_\varkappa|$ be possibly high. In the present paper only electric properties will be discussed. All values of pressure are given in atmospheres, where:

$$1\ \text{atm} = 1\ \text{kg/cm}^2 = 0.0980665\ \text{MN/m}^2$$

High-pressure Resistance Gauges with Metal Sensors

The manganin sensor is one of the most populare resistance metal sensors for measurements of high pressures [3]. The relative change of electric resistivity with increasing pressure and temperature for Russian and German manganin is diagramatically presented in Fig.1

In the range up to 6000 atm $\alpha = [\partial R/(R_0\,\partial P)]_T$ decreases linearly with the growing pressure:

$$\alpha_P = \alpha_0 + \alpha_1 \cdot P \qquad (1)$$

where α_0 dependes on the kind of wire, its diameter, and heat treatment [2]. At room temperatures we have:

$$\alpha_0 = (2{\cdot}0 - 2{\cdot}6) \times 10^{-6} \text{ atm}^{-1}$$

$$\alpha_1 \approx -5 \times 10^{-12} \text{ atm}^{-2}$$

For two kinds of wire α_0 increases with growing temperature (cf. Fig.1) where

$$\delta = [\partial\alpha_0/(\alpha_0 \partial T)]_P = 1 \times 10^3 \text{ deg}^{-1}$$

but $\alpha_1 \approx$ const. in the range 15 to 30°C.

In the range 6000 to 16,000 atm. α_P also decreases linearly with growing pressure (Fig.2) but at a rate about half that observed up to 6000 atm. The relative variations of resistivity with growing temperature are given for all manganin wires by the following parabolic function [3]:

$$\Delta R/R_{20} = at^2 + bt + c \tag{2}$$

where a,b,c depend on the kind of wire, heat treatment and the range of pressures (Table 1).

Czaputowicz constructed a new kind of manganin sensor consisting of two kinds of wire, Russian and German, connected in series. In this sensor $\beta = [\partial R/(R_0 \partial T)]_P$ is about ten times less than in the standard Russian, English or German manganin wires in the temperature range 17 to 27°C and the maximum error in the pressure reading due to temperature variation is only 2 atm. It allows for measuring both relatively small pressures (up to 1000 atm) and dynamic pressures [4].

High-pressure Resistance Gauges with Semiconductor Sensors

The application of pure (non-doped) semiconductor crystals of Te and InSb as high-pressure sensors was discussed by the present authors at the IMEKO-IV Conference [1]. However, since in practice all semiconductor materials are contaminated, it seems justified to express the basic parameters of the semiconductor resistive sensor by the value of the effective energy gap E^* and the effective energy gap pressure coefficient $a^* = (\partial E^*/\partial P)_T$ which fulfil the equation:

$$R/R_0 = \exp\ (E^* - a^*P)/(2kT) \tag{3}$$