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Thin-Film Temperature Sensor

A thin-film capacitor sensor has been developed for measuring the rapid temperature changes in fluid streams. The sensor withstands contacts with various corrosive fluids, high fluid-flow rates, and the turbulences caused by rapid changes in flow rates.

The heart of the sensor is a temperature-dependent thin-film capacitor. Its temperature coefficient α is defined by

$$\alpha = \frac{1}{C}\frac{dC}{dT} \qquad (1)$$

where C is the capacitance and T is the temperature in degrees Kelvin. Thin dielectric films are generally known to have a large α.

The capacitor is part of a resonant bridge circuit (Figure 1), which produces an ac voltage that is proportional to temperature. The output voltage V for a given temperature change ΔT is described by

$$V = V_0 \alpha Q \Delta T \qquad (2)$$

where V_0 is the initial amplitude of the harmonic voltage applied across the capacitive element. In Figure 1, the capacitive element is represented in the dashed box by its parallel equivalent capacitance C and resistance R.

If low-loss coils L are used, the circuit quality factor Q is determined by the capacitive elements, namely

$$Q = \omega RC \qquad (3)$$

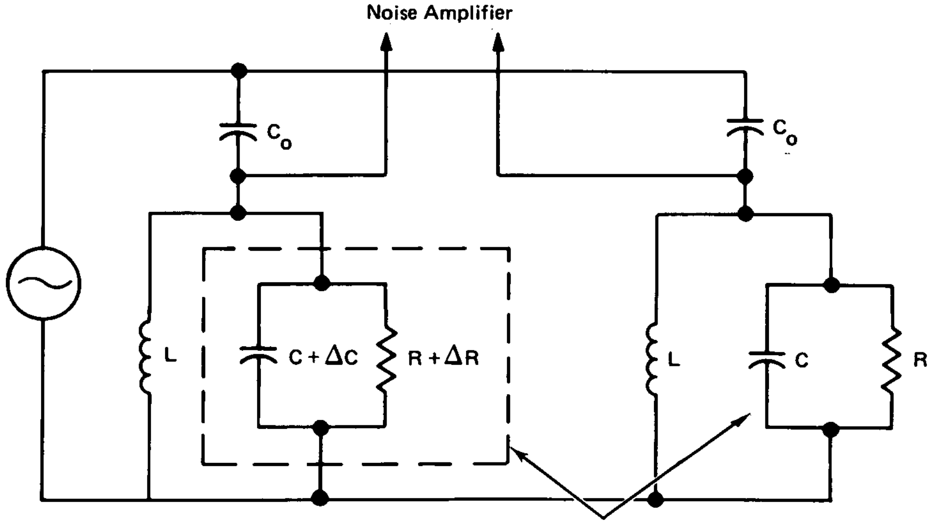

Figure 1. Resonant Bridge Circuit

(continued overleaf)

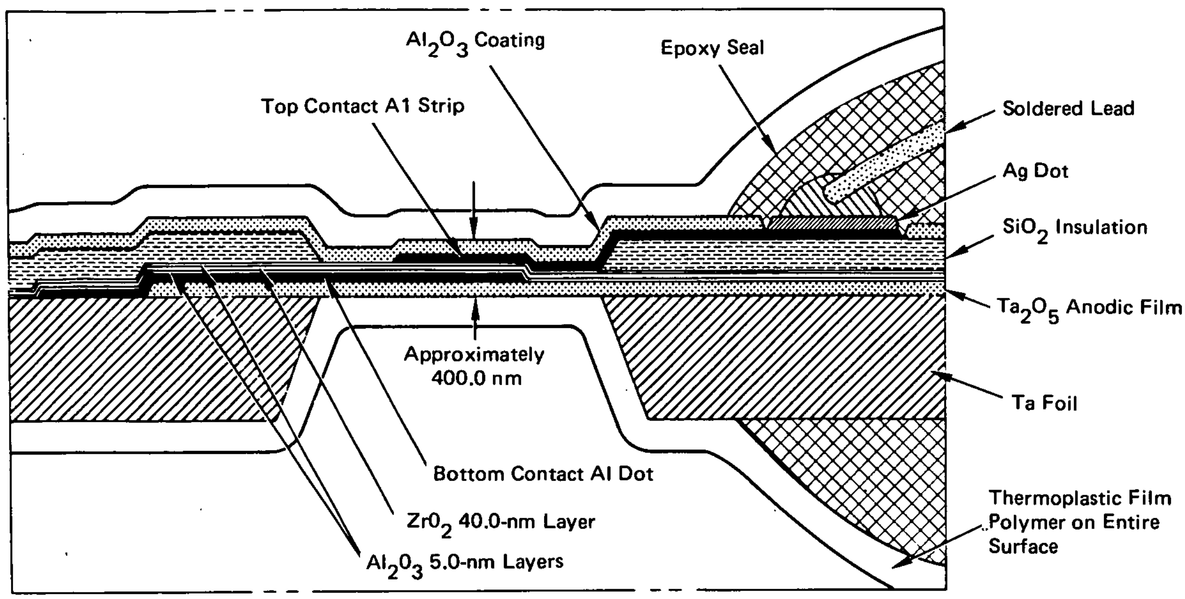

Figure 2. Temperature Sensor Structure

In this case, Q remains nearly constant for a wide range of frequencies ω, because R is inversely proportional to ω. The important parameters, therefore, that determine the temperature sensitivity of the sensor are α and Q, as indicated in equation 2. The resonant bridge circuit produces an output voltage larger by the factor Q than the voltage from a simple capacitance bridge without coils.

The sensor consists of a tantalum foil supporting a thin-film capacitive element, as shown in Figure 2. The foil is 99.8-percent-pure tantalum approximately 0.025 mm (0.001 in.) thick. The capacitive element is formed by the vapor deposition of successive layers of aluminum, aluminum oxide (Al_2O_3), zirconium oxide (ZrO_2), silicon dioxide (SiO_2), and aluminum. The aluminum strips form the capacitor electrodes, and the zirconium oxide with the aluminum oxide layers form the dielectric. In addition, a circular window approximately 0.38 mm (0.015 in.) in diameter is etched through the tantalum foil to the anodic film (Ta_2O_3). The entire sensor is coated with a thermoplastic polymer, which provides chemical protection and electrical insulation.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
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Reference: TSP74-10100

Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,676,754). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

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