CHARACTERIZATION AND COMPENSATION OF TEMPERATURE EFFECTS IN A QCM SENSOR IN LIQUID MEDIA

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Abstract

In many scientific and industrial applications, measurement instrumentation of very high accuracy is required to control and to study the evolution of various physical, chemical or biological processes. The piezoelectric oscillators are electronic circuits fixing their oscillation frequency by means of a piezoelectric crystal resonator. The oscillation frequency depends on the material characteristics, on the associated electronic circuit and on the environment conditions. The quartz crystal microbalance (QCM) is a thin plate of piezoelectric crystal with one rigidly attached metal film electrode on each side. The crystal is made to vibrate at its resonant frequency by inserting it in the feedback path of an oscillator circuit. In gravimetric applications, the crystal is in direct contact with its environment and the changes in the crystal resonant frequency, caused by environment changes, are used as analytical signal. In particular, the changes of mass deposited on the crystal surface, are directly reflected in frequency changes in such a way that an increase in mass, will cause the circuit oscillate more slowly.

The crystal oscillation frequency depends on the temperature in two different ways. Quartz crystals have a well defined response to temperature; in fact, they are sometimes used for very accurate temperature measurement. Therefore, a liquid temperature change modifies the frequency. This would greatly diminish the ability of the QCM to measure mass flux in liquid media, independently of temperature if we were not able to do anything about it.

In order to develop a temperature compensate QCM sensor working in liquid media, to use it in applications of long duration, hours even days (for instance, in electrochemical applications), an oscillator and liquid temperature control system was developed. First, a regulator temperature circuit was introduced in order to avoid frequency changes due to oscillator temperature changes. Second, a heater to control liquid temperature was used to avoid liquid temperature changes in laboratory-controlled experiments. However, the liquid temperature cannot be controlled in several applications (e. g. sea-water immersed sensor). In last case, with the objective of compensating the QCM sensor temperature working in liquid media, a temperature characterization was carried out using the developed system. In this way, a precise measurement of the frequency variation due to mass deposition can be obtained in the measurement system by means of this temperature compensation. Like this, the developed QCM sensor allows the measurement of mass changes with resolution about 161 pg/cm² using a 9 Mhz AT-cut quartz crystal.