Influence of frequency variation value on QCM detection of Micro-mass particles

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Abstract. The core of QCM sensor is quartz crystal vibration. According to the piezoelectric effect of quartz crystal, when alternating voltage is applied to the quartz crystal, the quartz crystal will vibrate. When the frequency of oscillation circuit is consistent with the natural frequency of quartz crystal, resonance will be generated. It is found that under certain conditions, the natural frequency of quartz crystal vibration changes with the adsorption mass when other substances are adsorbed on the surface of quartz crystal vibration. According to this principle, the QCM sensor makes a sensitive film on the quartz crystal vibrating surface, and USES the sensitive film to treat the adsorption effect of the measured substance, and converts the concentration signal of the substance to the frequency signal for detection. This project USES QCM sensor to detect pollution on insulators.

Keywords: quartz crystal microbalance; sensor; sensitive film; frequency signal; power unclean.

1. Introduction

Physicist Sauerbrey put forward the famous Sauerbrey equation (Equation 1), namely the relationship between the vibration frequency change value of quartz crystal and the adsorbed mass, which laid the theoretical foundation for the practical application of quartz crystal microbalance, and made it widely used in meteorological monitoring [1].

In 1959, a German physicist Saubery put forward in the frequency of the quartz crystal surface adsorption with rigid film material there is a linear relationship quality, namely the Sauerbrey equation: Saubery equation is the base of the QCM design, when the electrode deposited on quartz crystal has the adsorption material, film forming, it has a fixed frequency f0, when membrane molecule by polar adsorption and diffusion to accommodate a certain quality of gas molecule, its frequency shift frequency Δ f will occur, through the equation can be obtained by the change of quality Δ m [3, 4].

\[
\Delta f = -\frac{2f_0^2}{A\sqrt{\rho \mu}} \Delta m
\]  

(1)
Is the fundamental frequency of quartz crystal; is the quartz crystal density; is the change in mass; is the shear modulus of quartz crystal; A is the effective contact area. According to the change of QCM oscillation frequency, the mass of adsorbed analyte on the surface can be obtained. Sauerbrey equation is only applicable to the detection of rigid substances that do not consume any energy during the oscillation process, such as metal coating, metal oxide film, adsorption film, etc [5].

2. Experimental Details
To study the influence of different electrode sizes and effective thickness of electrode regions on the system resonance frequency and energy trapping, so as to provide a theoretical basis for the circuit design of QCM quartz chip [6, 7].

![Fig. 1 Different cut crystal test circuits.](image1)

 Generated by DSP to write control word, waveform generator frequency controllable sinusoidal signal, sine signal through the drive circuit drive the QCM design resonators [8], resonator output signal is extracted by the signal processing circuit processing and then by the A/D system collection, DSP system reads A/D acquisition can get the corresponding point of the output signal frequency, to complete A collection process.

![Fig. 2 Crystal oscillating circuit.](image2)

3. Results and Discussion

3.1. Frequency value output circuit
In the natural environment, the influence of pollution attachment puts forward higher requirements on quartz crystal, and the simple voltage amplitude cannot meet the detection requirements of environmental pollution. Through market research and a large number of tests. According to the test data of its circuit board, forward research and development, and optimize and upgrade the circuit, improve the supply voltage at the same time, output frequency, to overcome the frequency value is easy to miss the problem [9, 10].

Choice of electrode double - sided and single - sided coating. It is mainly related to the establishment of the corresponding relationship between the new pollution micro-quality detection method and the traditional standard method. Quartz crystals with the same shape of electrodes were selected for double-sided coating. Covered ash choose single big test surface was, on the one hand, single electrode test method is the general practice in the field of quartz crystal application, on the other hand, this way not only can establish relationship with the traditional standard impurity detection method, can also
understand quartz crystal micro balances environment comparative analysis on the effect of impurity detection field.

3.2. Different electrode contamination tests
Due to the narrow detection range of voltage amplitude, the crystal is prone to jump and fluctuation after coating. On the basis of this, the optimization and upgrading are carried out, and frequency value detection and output are taken as the purpose of the second stage.

(1) 5M. Au electrode

![Fig. 3 Au 5M electrode diagram of indoor micromass and frequency value.](image)

(2) 8M. C-Si electrode

![Fig. 4 8M C-Si electrode diagram of indoor micromass and frequency value.](image)

(3) 8M. Au electrode
Crystal manufacturers and circuit vendors have been reflected, but the view is not consistent. When the coating thickness or frequency of the crystal surface changes more than 1% of its own thickness or fundamental frequency, the natural frequency of the crystal does not change and is shown as 0. This
phenomenon is reflected in the circuit test of the second phase frequency, but it is not clear whether it is the crystal problem or the circuit cause.

4. Conclusion

It is mainly reflected in the outdoor samples. For example, as the time goes on, about 1-1.5 months, after the ash coverage increases, the crystal has no data in the test circuit with rated voltage of 5V. However, when the input voltage increases to 10V, the frequency data of 10M crystal appears with good regularity. Quartz crystal cutting has prominent limitations. Currently, the main cutting shape in the domestic market is AT cutting, and other cutting shapes cannot be purchased, or the price is very expensive. When manufacturers receive few orders, they do not arrange production AT all, so the tested quartz crystals are AT cutting, and other cutting crystals cannot be tested.

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