Quartz Crystal Microbalance Measurements.

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A quartz crystal microbalance (QCM) measures a mass variation per unit area by measuring the change in frequency of a quartz crystal resonator. The resonance is disturbed by the addition or removal of a small mass due to oxide growth/decay or film deposition at the surface of the acoustic resonator. The QCM can be used under vacuum, gas phase and liquid environments. It is useful for monitoring the rate of deposition in thin film deposition systems under vacuum. In liquids, it is highly effective at determining the affinity of molecules (proteins, in particular) to surfaces functionalized with recognition sites. Larger entities such as viruses or polymers are investigated, as well. QCM has also been used to investigate interactions between biomolecules. Frequency measurements are easily made to high precision (discussed below); hence, it is easy to measure mass densities down to a level of below 1 μg cm^{-2}. In addition to measuring the frequency, the dissipation factor (equivalent to the resonance bandwidth) is related to the sample's viscoelastic properties and is often measured.

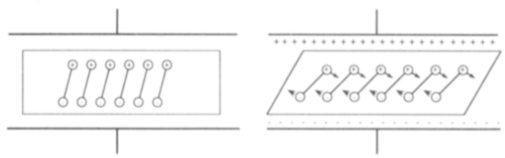

Figure 1. Schematic representation of the converse piezoelectric effect for shear motion. The electric field induces reorientation of the dipoles of the acentric material, resulting in a lattice strain and shear deformation of the material. Direction of shear is dependent upon the applied potential while the extent of shear strain depends on the magnitude of the applied potential.

The Sauerbrey equation was developed by G. Sauerbrey in 1959 as a method for correlating changes in the oscillation frequency of a piezoelectric crystal with the mass deposited on it. He simultaneously developed a method for measuring the characteristic frequency and its changes by using the crystal as the frequency determining component of an oscillator circuit. His method continues to be used as the primary tool in quartz crystal microbalance experiments for conversion of frequency to mass and is valid in nearly all applications. The Sauerbrey equation is defined as:

$$\Delta f = -\frac{2f_0^2}{A\sqrt{\rho_q \mu_q}}\Delta m$$

f_0 Resonant frequency (Hz)

Δf Frequency change (Hz)

Δm Mass change (g)

A Piezoelectrically active crystal area (Area between electrodes, cm^2)

ρ_q Density of quartz (= 2.648 g cm^{-3})

μ_q Shear modulus of quartz for AT-cut crystal (= 2.947×10^{11} g cm^{-1} s^{-2})

The equation is derived by treating the deposited mass as though it were an extension of the thickness of the underlying quartz. Because of this, the mass to frequency correlation is largely independent of electrode geometry. This has the benefit of allowing mass determination without calibration.

Sources: https://en.wikipedia.org/wiki/Sauerbrey_equation