Quartz Crystal Microbalance and Electrochemical Quartz Crystal Microbalance analyzers

Fig.1 QCM and EQCM analyzers

Quartz crystal microbalance and electrochemical quartz crystal microbalance (see Fig. 1) have been widely employed for the determination of substance deposited onto the crystal, studies of ion-transport processes in polymer films, biosensor (DNA and Protein research) developments, and investigations of the kinetics of adsorption/desorption of adsorbate molecules. There is the influence of temperature and noise on QCM and EQCM, the cooling constant temperature oven (TB-1, 0~50C?) have to be used.

The mass sensitivity of QCM originates from the relationship between the oscillation frequencies, as shown below.

$\Delta f = -2f_0^2 \Delta m$ / ?A sprt $(\mu\rho)$?

Where f_0 is the resonant frequency of the fundamental mode of the crystal, A is the area of the gold disk coated onto the crystal, ρ is the density of the crystal (=2.684 g/cm^3), and μ is the shear modulus of quartz (=2.947? 10^{10} g/cm?s^2). Using a crystal with a 7.995-MHz fundamental frequency (as used in our measurements) as an example, a net change of 1Hz corresponds to 1.34ng of materials adsorbed or desorbed onto the crystal surface of an area of 0.196 cm^2.

The Quartz crystal microbalance is a piezoelectric device capable of extremely sensitive mass measurements. The flow-injection quartz crystal microbalance (FI-QCM) are used to study the immobilization of the probe, to estimate the extent and efficiency of the hybridization of DNA, and to examine the effect of using a different alkanethiol to reorient the preformed film for a higher hybridization efficiency. FI-QCM should be helpful in the use of thiolated oligonucleotides for heterogeneous DNA sensor development and as building blocks for constructing interesting and important materials.

liquid/flow cell allows frequency measurement of a crystal when one side is exposed to a solution. During frequency measurement, the other side of the crystal must be dry and exposed to air.

The cell is composed of acrylic for flow cell and peak for static, with an upper and lower piece held together with two screws (see Fig. 2 a). The crystal is centered between two O-rings in the upper and lower pieces and the screws are tightened with sufficient force to seal crystal (see Fig.2b ~2f). The liquid/flow cell with enclosed crystal can be attached to the oscillator crystal socket.

Fig. 2 a Fig.2 b Fig.2 c

Fig.2 d Fig. 2 e Fig. 2 f

Static QCM

The cell allows the use of liquid samples with a crystal in two ways. One side of the cell is constructed as a static system (see Fig.3 a).

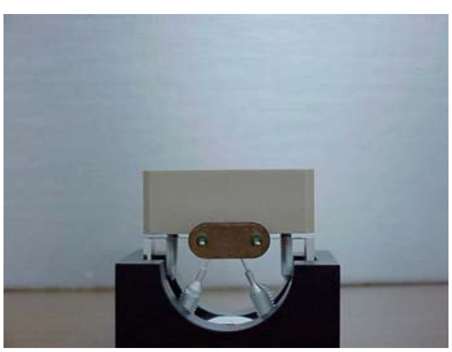

Fig.3 a Static QCM Detection

In this case, one face of the crystal is exposed to a 70ul acrylic chamber. The chamber is connected to an external peristaltic or syringe pumping system through common 1/4-20 thread fitting. Two flangeless fitting for 1/16 inch OD tubing are included with the cell. The static QCM is suitable for the aprotic non-aqueous solvent.

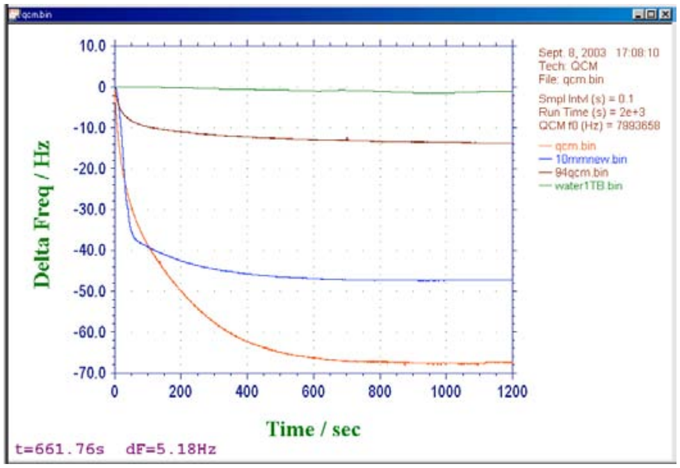

Fig. 3 b Static gold QCM in the different Concentration thiol: a: water; b : 1mM; c : 10 mM; d : 50 mM

FI-QCM

The flow side of the acrylic cell has a 70ul chamber over the crystal. The chamber was designed to reduce the potential of air bubbles remaining on the crystal after filling from the dry state and to allow air bubbles in the liquid phase to pass out without sticking to the crystal. MAB2 pump is used.

Fig. 5 a FI-QCM detection

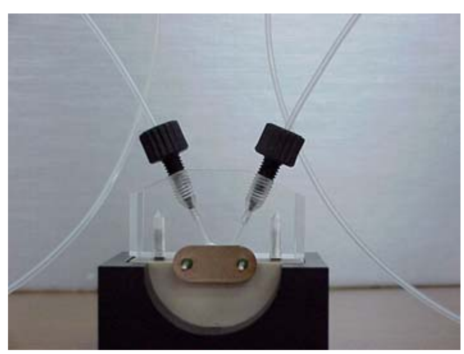

Fig. 5 b FI-QCM flow cell

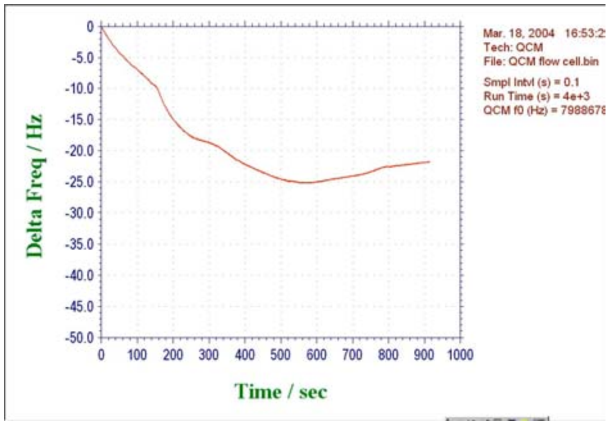

Fig. 5 c FI-QCM data.

EQCM

When used as an in situ technique for measuring mass changes at electrode surface, one of the EQCM electrodes is used simultaneously to provide for the alternating electric field, which drives the oscillation of the crystal and as the working electrode in the electrochemical cell. Thus, the EQCM experiment involves the measurement of the various electrochemical parameters, such as potential, current, and charge, at one of the EQCM electrodes and the simultaneous measurement of the oscillation frequency of the piezoelectric crystal from which, in favorable cases, minute mass changes at the electrode may be inferred. The EQCM has been used to study monolayer and multiplayer depositions and dissolutions, mass transport in polymer films on electrodes, corrosion processes at electrodes, electroless depositions, and mass changes caused by protein adsorption adsorption at electrodes.

The QCM is integrated with CHI potentiostat and galvanostat, making the EQCM (see Fig. 6 b) study simple and convenient. Cyclic Voltammetry (CV) , Linear Sweep Voltammetry (LSV), Chronoamperometry (CA) Amperometric I-t Curve (i-t) and Chronopotentiometry (CP) can be measured with QCM.

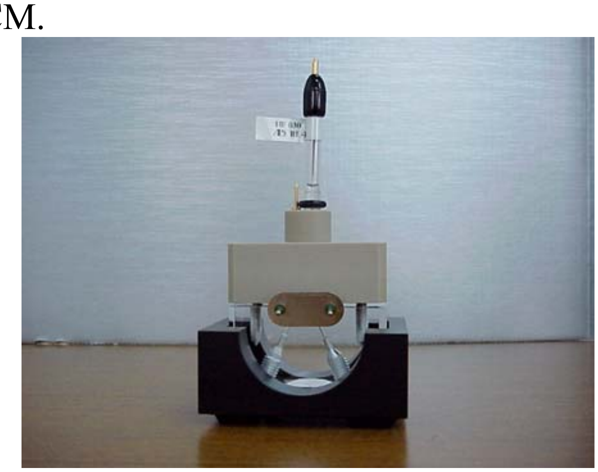

Fig. 6 a EQCM Cell

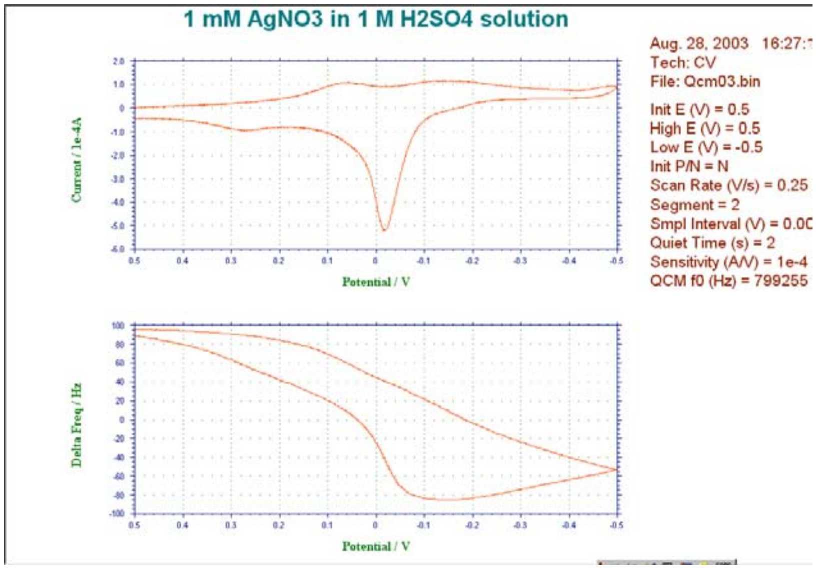

Fig. 6 b The gold QCM with cyclic voltammetry in 1mM $AgNO_3$/1M H_2SO_4 solution.