Measure the mass of molecular layers forming on the surface with nanogram sensitivity. For example, 1% or less of a protein monolayer can be detected.

Structural changes to be measured simultaneously so as to distinguish between two similar binding events or observe a phase transition in bound layers.

Real time analysis allowing real-time recording and evaluation of kinetics.

Label free No need for labelling of molecules, the instrument measures the molecules themselves.

Flexible choice of surface including metals, polymers and chemically modified surfaces. Any surface that can be applied as a thin film can be used.

Flow measurements Chamber specifically designed for flow measurements in a temperature-controlled environment.

4-Sensor chamber allows higher throughput and makes reproducibility easier.

Electrochemistry chamber Study electrochemical reactions simultaneously by using an optional electrochemistry chamber.
As the second generation of Quartz Crystal Microbalance with Dissipation monitoring (QCM-D) from Q-Sense, the E4 offers the opportunity to study molecular interactions and molecular adsorption to many different types of surfaces. Applications include proteins, lipids, polyelectrolytes, polymers and cells/bacteria interacting with surfaces or with previously bound molecular layers.

The instrument determines the mass of very thin surface bound layers and simultaneously gives information about their structural (viscoelastic) properties. It is based on the patented QCM-D technique, an extremely sensitive and fast technique providing multi-frequency and dissipation data that are needed to fully understand the state of molecular layers bound to the sensor surface.

Today QCM-D plays a key role in the investigation of biomaterials, development of surfaces for biosensing and biochips and in fundamental research to understand processes taking place on surfaces or in thin films. It is often used as a complement to optical and imaging techniques such as Surface Plasmon Resonance (SPR) and Atomic Force Microscopy (AFM).

Q-Sense E4 is a complete turnkey instrument and includes everything needed to quickly get started and produce high quality data. The instrument has four flow modules, each holding one sensor. The flow modules can be used in any serial or parallel configuration to suit different measurements needs. It also includes software that allows the system to extract the thickness, viscosity and elasticity of adsorbed layers as well as fitting to kinetic models.

1. Mount quartz crystal sensors in the temperature controlled chamber. Four sensors are fixed in removable flow modules with inlet and outlet. The quartz crystal sensors may be pre-coated with, for example, metals, polymers or SAMs.

2. Introduce sample and conduct in-situ experiments. The chosen experimental procedure is run; for example, buffer followed by sample A and sample B and back to buffer.

3. Follow results in real time on the computer screen. Frequency changes reflect mass changes taking place on the sensor surface, dissipation changes reflect changes in the adlayer’s viscoelastic properties.

4. Analyse and present results in the software QTools. Extract mass, thickness, viscoelastic properties, kinetic constants, adsorption phases and so on.
Kinetics of molecular interactions

It is possible to estimate kinetic constants by monitoring adsorption upon sequential increase of the bulk concentration followed by monitoring of the desorption at zero bulk sample concentration. In this example linkage of reversibly bound cholesterol-DNA to a lipid bilayer was monitored and kinetic constants were determined to $K_d = 16.7 \pm 4 \text{ nM}$ and $k_{off} = 5.8 \times 10^{-4} \text{ s}^{-1}$ ($k_{off}/k_{on} = K_d$). It is assumed that the amount of coupled water per molecule does not vary with coverage.

The heart of the system is a quartz crystal sensor that consists of a thin disc of crystalline quartz sandwiched between two electrodes. An AC voltage applied over the electrodes induces a small shear oscillation in the sensor at resonance. The oscillation will decay exponentially if the driving AC voltage is turned off. In the QCM-D technique, this decay is recorded and two parameters, the resonance frequency ($f$) and the dissipation ($D$) are extracted.

The resonance frequency of the sensor crystal depends on the total oscillating mass. For thin, rigid films the Sauerbrey relation, \( \Delta m = -k \Delta f \) may be used to calculate the mass of adsorbed layers following the oscillation of the sensor.

A deposited film that is soft and viscous will dissipate energy (via frictional losses in the film) and the sensor oscillation is damped. The dissipation gives information about the structure of the thin film attached to the sensor. A compact globular protein adsorbed to the surface gives rise to only a low dissipation (rigid film) while an elongated protein with a lot of coupled water results in higher dissipation (soft film).

By using multiple frequency and dissipation data it becomes possible to calculate mass, thickness, viscosity and elasticity, using a viscoelastic model, outside the Sauerbrey regime. These calculations are done in software Q-Tools, included in the E4 system.