Insplorion

Acoulyte

Product and Technology Information

- *Insplorion™ Acoulyte enables simultaneous real-time measurements using Insplorion's NanoPlasmonic Sensing (NPS) and Q-Sense Quartz Crystal Microbalance with Dissipation monitoring (QCM-D)*
- *Real-time data on changes in dry (optical) mass, wet (acoustic) mass, and viscoelasticity simultaneously, for the same sample and on the same surface.*
- *Complementary information that will help in understanding complex surface and thin film processes.*
- *Measure diffusion processes and obtain depth profiling of thick films (> 100 nm).*

Combining NPS and QCM-D

The Insplorion Acoulyte has all the necessary hardware and software components to add NPS measurements to a Q-Sense Explorer (E1) or Analyzer (E4) instrument when equipped with the Q-Sense window module (QWM 401).

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Insplorion's NPS Technology

NPS is an optical technology that utilises thousands of gold nanodisc sensing elements on a surface. (Other nanostructure shapes are also available upon request. For more information see Insplorion's sensor broshure.) The nanodiscs (100 nm in diameter and 20 nm high) form a semi random pattern on the surface and cover ca. 10 % of the surface area. White light is used to excite each disc's localized surface plasmon resonance (LSPR). When excited, the LSPR probes the nano-environment around the disc and returns modified light that describes what it found. By collecting and analysing the returning light, information is obtained about chemical and physical changes in the nanodiscs' closest environment. A variety of processes, which give rise to changes in the refractive index (dielectric function) of the material around the nanodiscs, can be detected using NPS. The sensitivity of the nanodisc sensors decays exponentially from the nanodisc surface with a decay length* of approximately 30 nm.

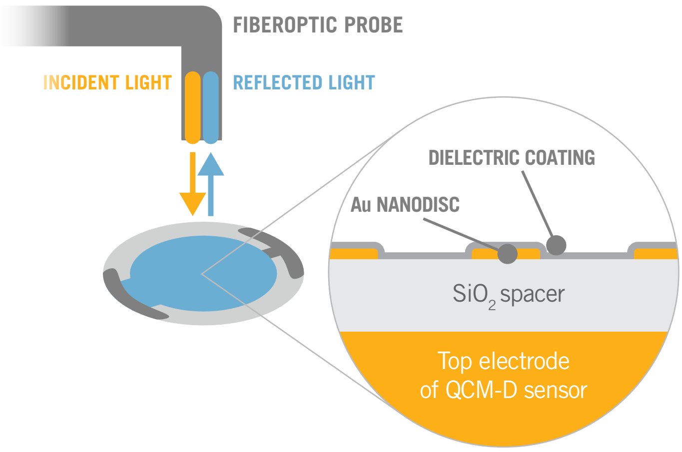

Figure 1: During a measurement, the Acoulyte sensor is irradiated with white light. At the LSPR wavelength, part of the incoming light is absorbed and scattered by the gold nanodiscs. The remaining light is transmitted through the gold nanodisc layer and the SiO_2 spacer layer. It is, subsequently, reflected at the top electrode of the QCM-D sensor and then interacts with the gold nanodiscs one more time. The light that has not been absorbed and/or scattered by the gold nanodiscs is picked up by the fiberoptic probe and transmitted to the spectrometer where its intensity as a function of wavelength is detected.

Q-Sense QCM-D Technology

Quartz Crystal Microbalance with Dissipation monitoring (QCM-D) utilises an oscillating quartz crystal to measure the mass and viscoelasticity of thin films on the crystal surface. The quartz crystal is sandwiched between a pair of gold electrodes. The sensor is excited to oscillate at its resonance frequency by applying an alternating voltage between the electrodes. The resonance frequency depends on the total oscillating mass of the sensor and any layers adhering to its surface, including coupled solvent. The resonance frequency decreases when a thin film is attached to the sensor surface. If the film is thin and rigid the decrease in frequency is proportional to the mass of the film. In QCM-D both the resonance frequency and energy dissipation of the quartz crystal are measured. The dissipation provides information about the viscoelasticity of the adhering layers.

** The decay length is defined as the distance from the surface where the sensitivity has been reduced by a factor 1/e=0.368 of its initial value.*

NPS + QCM-D

The Acoulyte can be used to measure the dry mass (NPS), wet mass (QCM-D), the amount of bound solvent molecules (NPS and QCM-D) and viscoelasticity (QCM-D) of adsorbed surface films. The different sensing depths of the two measurement techniques (< 30 nm for NPS and at least 300 nm for QCM-D) opens up the possibility to do depth resolved measurements within adsorbed films that have a total thickness of more than 100 nm. Further information is provided in the figure on the opposite page.

The intensity of the probing light beam is low and does not cause any heating of the sample or Acoulyte sensor and, therefore, does not influence the QCM-D reading.

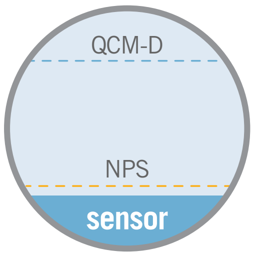

Figure 2: Schematic illustration of the difference in probe depths of NPS and QCM-D. The sensitivity of both techniques decays exponentially from the surface with a decay length of ca. 30 nm for NPS and several hundred nanometers for QCM-D.*

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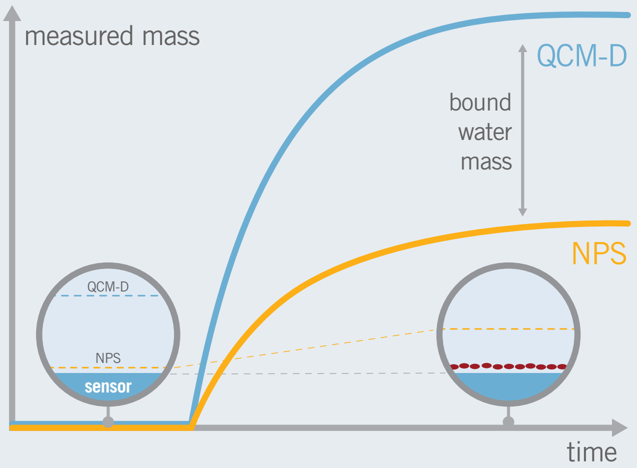
	Thin layers	Thick layers

Hydrated molecules

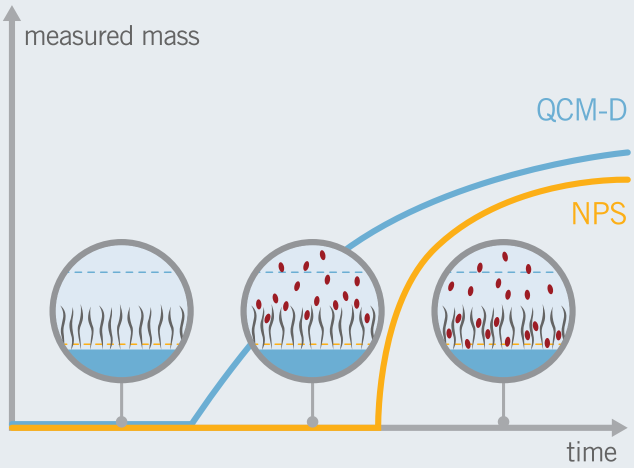
Adsorption of small hydrated molecules



- Both NPS and QCM-D probes the entire film.
- NPS measures the dry mass of the adsorbed molecules.
- QCM-D measures the wet mass of the adsorbed molecules.

Diffusion of molecules into a hydrated film

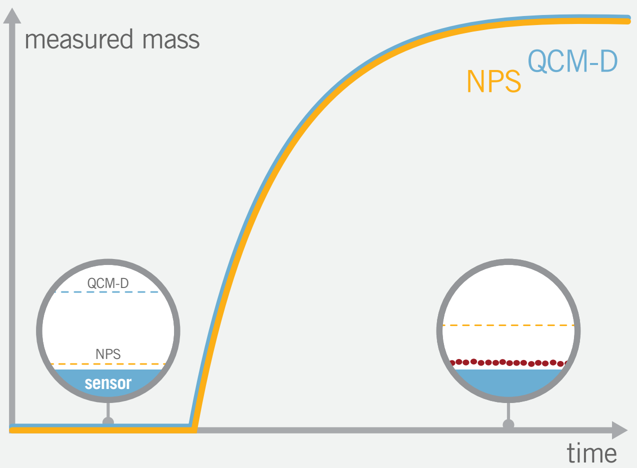
(e.g. polymer or hydrogel)



- NPS measures the dry mass of the molecules absorbed < 30 nm from the surface.
- QCM-D measures the change in mass due to molecular absoption and associated water loss.
- The rate of mass increase measured by QCM-D is smaller than that measured by NPS due to water loss.

Non-hydrated molecules

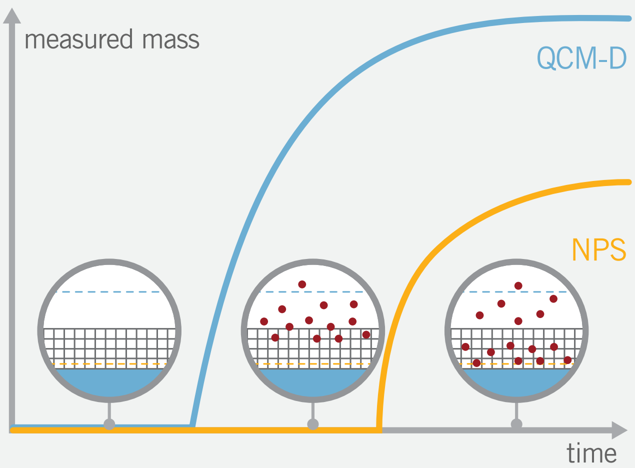
Adsoprtion of small non-hydrated molecules



- Both NPS and QCM-D probes the entire film.
- Both NPS and QCM-D measure the (dry) mass of the adsorbed molecules (no bound water).

Adsorption of non-hydrated molecules in rigid-film

(eg. gas molecule adsorption in a metal organic framework)



- NPS measures the mass of the molecules < 30 nm from the surface.
- QCM-D measures the mass of the molecules adsorbed in the entire film.

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Measuring is easy

Starting an Acoulyte measurement is easy. The different steps are described in the picture sequence below:

1

Mount the Acoulyte sensor in the Q-Sense window module.

2

Mount the window module in the Q-Sense instrument.

3

Connect fluidics and attach the Acoulyte module.

4

Configure the measurement in Insplorer and Q-Soft.

Specifications

Measurement cell

Determined by the Q-Sense window module (QWM 401)

Sensors

Size	14 mm diameter
Substrate	QCM-D sensors with SiO_2 coating
Surface	Nanostructured gold
Standard coatings	SiO_2, Al_2O_3, TiO_2

Measurement characteristics

Light source	Tungsten-Halogen lamp
Sensitivity*	0.03 monolayer
Measured spot diameter	3 mm
Time resolution	Up to 10 sample points per second
Typical noise	<0.01 nm in wavelength
Wavelength range	450-1000 nm

The QCM-D measurement is not affected by the Acoulyte.

Dimensions (Width x Depth x Height)

Acoulyte module	8x5x3 cm
Insplorion optics unit	25x27x9 cm

Software

Compatible software	Insplorer
Operating system	Microsoft Windows compatible
Output data format	ASCII compatible for straightforward use with any graph drawing software
Analysed parameters	Multiparameter readout (e.g. resonance wavelength and extinction at the LSPR peak)

*Estimate for a monolayer of bovine serum albumin molecules.