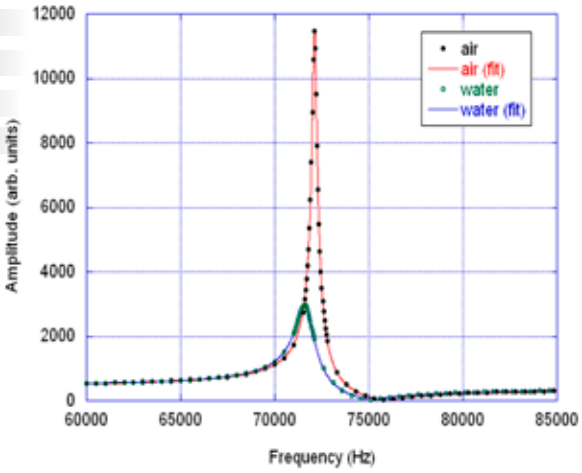
IMEGO
Solutions beyond sensors

MerMaid

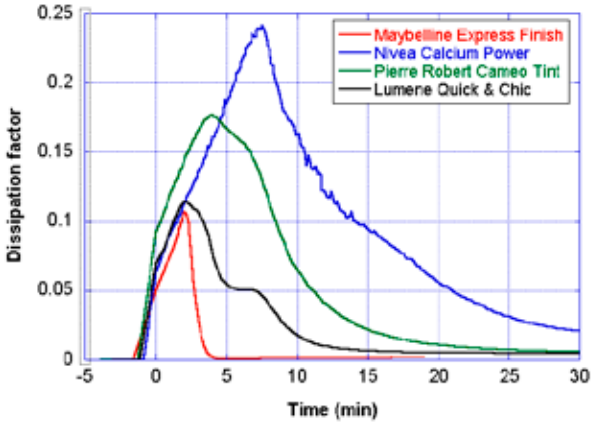
A unique instrument for liquid and thin film analysis

MER sensor

MERMAID is a unique measurement instrument for analysis of liquid and thin film properties using magnetoelastic resonance (MER) sensors. Dynamic events such as viscosity changes, phase transitions or bio film growth can be analyzed. The MER sensor can measure properties of either a coating on top of the surface or of the medium surrounding the sensor. MER sensors together with the MERMAID instrument are useful in many applications, such as food processing, biomedicine and polymer test and development.



The frequency response of a MER film placed in air and in water. The resonance frequency is shifted downward and the resonance peak is broadened when the film is placed in water. The viscosity in water can be determined from the shift in frequency and dissipation.

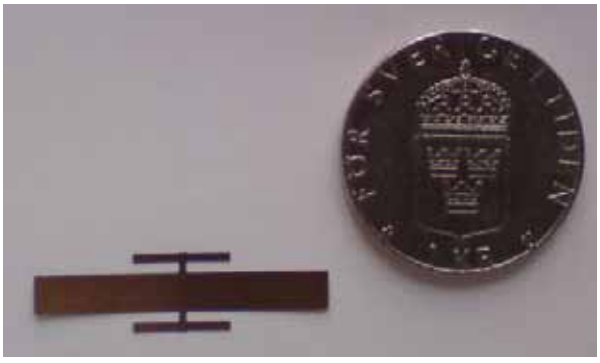


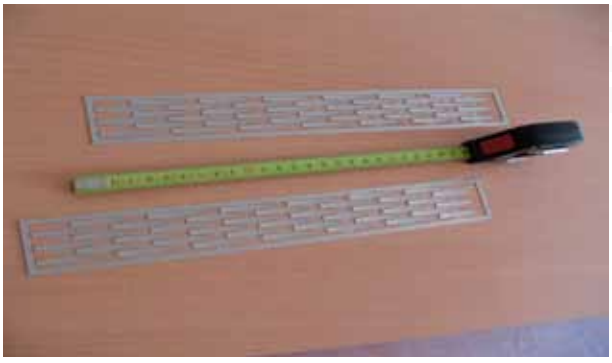
The measurement example shows the drying process of thin layers of nail varnish applied on the surface of a MER sensor. The nail varnish goes from viscous to elastic during the drying, which is reflected in the measurement. The slow long term curing process of the nail varnish is also seen in the data. The thicknesses of the applied paints were in range from 50 to 150 µm.

The innovative excitation and detection coil design allows the instrument to be very compact, allowing the MERMAID to be portable and easy to handle. The measurement is done by placing the MER sensor on top of the instrument, no additional components are required. The wireless detection of the sensor allows the sensor to be placed at a few centimeters distance from the MERMAID instrument, allowing the sensor to be for instance in a test chamber without any wires attached. The sensor can be read out through all non-metallic materials. The sensors are robust and easy to handle. In addition, the sensors are made of a low cost material, meaning that the sensors can be disposed after use at a low cost.

The detection method is based on continuous magnetic excitation of the MER film, using a magnetic frequency sweep across the resonance frequency of the sensor. The sensor oscillates longitudinally due to the magnetoelastic properties of the material. The MER sensor is either coated by or immersed in the substance under investigation. The shear wave emitted by the sensor penetrates approximately 1 – 10 µm into the surrounding material. The sensor is able to operate with a millimeter-thick coating or in a highly viscous fluid, but the sensor will only "see" 1 -10 µm into the material.

For a rigid layer on top of the sensor, the shift of the resonance frequency is proportional to the mass/thickness of the layer, the so called Sauerbrey relation. The mass sensitivity is in the order of 1 µg/cm2, for a 30 mm





*The MERMAID instrument is delivered together with a set of MER sensors. The left picture shows a sheet with 40 sensors. The standard sensor (right) has the dimensions 30 mm * 6mm * 0.03 mm corresponding to a fundamental resonance frequency of approximately 70 kHz. Custom made sensors, for instance with an anti-corrosion protection or gold plated are available upon request.*

long sensor. Hence, the thickness of a rigid layer can be measured with a sub-micron resolution. If desired, the mass sensitivity can be improved by using shorter sensors.

For a non-rigid layer or medium, for instance viscous or viscoelastic, the response is more complicated. The measurement software fits the acquired frequency response data to a model which returns the resonance and anti-resonance frequency together with amplitude and gamma of the sensor. The gamma factor of the system describes the damping and is closely related to the dissipation. The frequency response and dissipation of the sensor gives information of the surrounding media. A time dependent process occurring in the medium surrounding the sensor with give rise to a time dependent frequency and dissipation shift.

The MERMAID instrument comes together with PC software for running the system and for data collection, fitting and analysis. With the software it is possible to set measurement parameter, visualize the data, store the data, calibrate the instrument and perform data fittings of the result in a user friendly interface. In the system there is also a calibration procedure that is performed in the whole frequency range.

The MERMAID instrument is delivered together with a set of MER sensors. The standard sensor pattern is shown in the picture below, having the dimensions 30 mm * 6mm * 0.03 mm corresponding to a fundamental resonance frequency of approximately 70 kHz. Custom made sensors, for instance with an anti-corrosion protection or gold plated are available upon request.

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Property	Value	Comments
Frequency interval	10 – 250 kHz	Allow analysis of MER sensors with lengths between 9 mm to 210 mm
Sensor temperature range	< 150 °C	For temperatures below 0 °C and above 50 °C an external read-out coil is required.
Mass resolution	1 µg/cm2	The mass sensitivity can be improved by using shorter sensors.
Time resolution	≈ 5 s	The time resolution depends on the number of frequency points measured in each sweep. Each point takes approx 150 ms.
Sensor size	30*6*0.03 mm	The sensor size can be customized.
Instrument size	22*14*4 cm	

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