**Engineering of Quartz Crystal Resonators for Chemical and Biochemical Detection**

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## 1. Introduction

Acoustic-wave based sensors are known as devices highly sensitive to mass changes on a picogram scale and increasingly used in liquid environment. Those sensors are also known to respond to viscous properties of the liquid environment and viscoelastic properties of the coating material. Recently, the detection of interfacial phenomena could be shown.

Considering the different requirements of those application we developed a sensor system with quartz crystal resonators as sensing device for chemical and biochemical detection. Main subjects of engineering were universal use in liquid systems, simple handling of the sensor device, improved sensor interface electronics, multi-parameter data acquisition and web-based remote access.

## 2. Background

In a more general view quartz crystal resonators respond to changes of the so-called acoustic load impedance at the interface between the crystal and the resonator. The Acoustic Load Concept (ALC) especially allows the treatment of viscoelasticity. The Generalized Acoustic Load Concept (GALC) additionally allows the treatment of interfacial phenomena and irregularities unavoidable during., e.g., sensor functionalization. The ALC furthermore relates the acoustic load to measurable values: the commonly used shift of the resonant frequency and additionally a value proportional to acoustic energy dissipation, like the Q-factor or the motional resistance. Except for thin rigid layers the measurement of both values is required for unambiguous data interpretation. Biosystems quite often require more information, which can be provided by complete admittance spectra around fundamental frequency and overtone frequencies.

## 3. System Components

Handling of quartz crystal discs is quite complicated and fails under practical circumstances. Quartz on Ceramic (QUARC) overcomes this problem with a carrier system, which furthermore protects the second main surface of the quartz disc from liquid contact (Fig. 1). 4 x 4 sensor arrays on a single quartz wafer were fabricated by a combined photolithographic/ etching process (Fig. 2).

We developed improved sensor electronics for both active and passive quartz operation, including calibration. The oscillator can excite viscously loaded quartzes and has two outputs for frequency shift and motional resistance. A network analyzer like solution provides a complete admittance spectrum. Calibration routines compensate unavoidable influences from the measurement system.

The data acquisition unit is based on an FPGA and has 16 channels for frequency measurement, 8 analog channels, two specified for temperature measurement, and a 16 bit digital output. Remote access is realized with IPC@CHIP via ethernet or RS232.

Two systems have been developed for general purposes, the GasLab with 8 quartz crystal sensors for gaseous analytes and the LiquiLab with 4 quartz crystal sensors for liquid applications (Fig. 3).

*Figure 1: Quartz on Ceramic (QUARC) carrier*

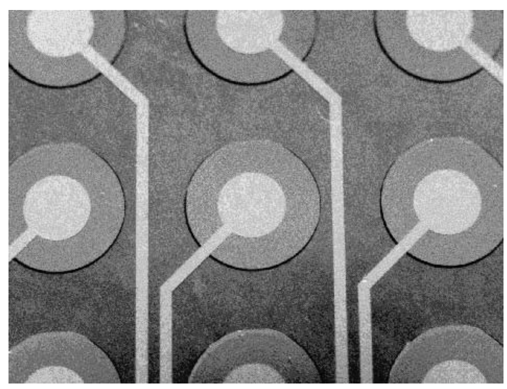

*Figure 2: Cutout of 4 x 4 quartz crystal sensor array*


*Figure 3: LiquiLab with 4 measurement chambers with pumps for pulse-free sample transport andminimized sample volume*