Subproject A4: „Multiple band sensor arrays for vibration monitoring based on near -surface silicon bulk micromechanics“

- **Dr. Jan Mehner**
- **Prof. Thomas Gessner**
- **Prof. Gunter Ebest**

Author: Dirk Scheibner

Vibration monitoring has become an important mean for wear state recognition of cutting tools, bearings, gears, engines and other highly stressed machine components. The majority of mechanical vibration used to identify the wear state is found in the frequency range from several Hertz to 10 kHz. At present vibration measurement systems are usually based on wide-band piezoelectric transducers combined with sophisticated analyzing electronics to observe the spectrum. Because of high costs, permanent monitoring is only feasible for extremely expensive machinery or in safety related applications. To apply permanent vibration monitoring to a wide range of industrial equipment low-cost vibration sensors are required.
For the characterisation of the wear state usually the observation of a few spectral lines is sufficient. This fact suggests a narrow band resonance operation of the sensor structures. Advantages of this frequency selective approach are the improvement of the signal-to-noise ratio and simplifications in the signal conditioning circuitry without a Fourier transformation as shown in fig. 1.

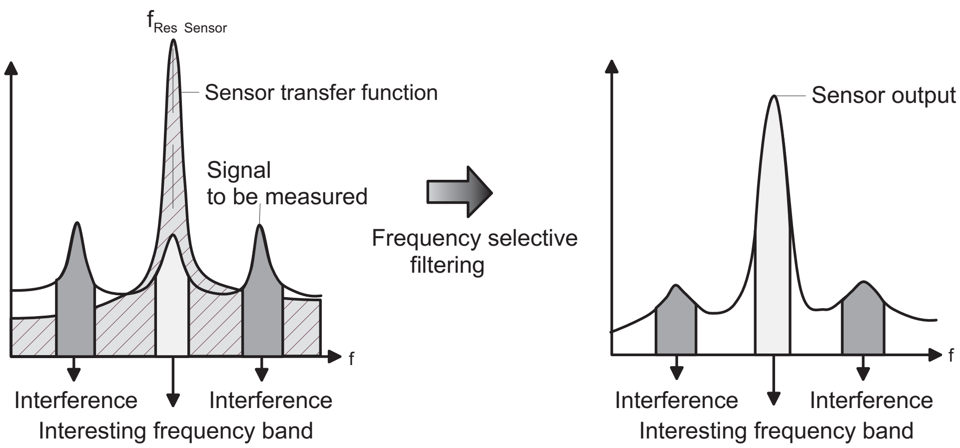
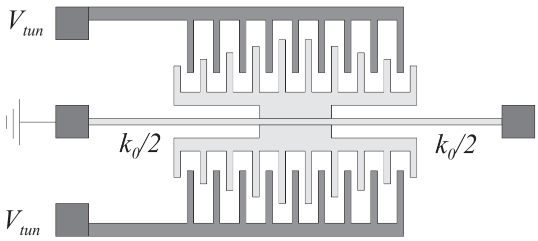


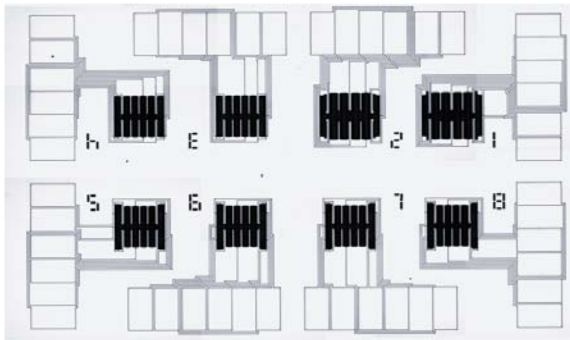
Fig. 1 Frequency-selective operation principle

The fixed resonance of such sensors limits their use to applications with well known and constant measurement frequencies. In this project we designed frequency selective capacitive sensor structures for the range from 1 to 10 kHz fabricated in a near-surface silicon bulk technology known as SCREAM (Single Crystal Reactive Etching and Metallization). The structures include a resonance frequency tuning capability by a control voltage which is an essential feature for a convenient device parameter adaptation to the desired measurement frequency. The tuning mechanism is based on electrostatic softening effects as shown in fig. 2a. By grouping several sensor structures with stepped base frequencies into an array the covered frequency range is largely extended (fig. 2b).



$$k_{total} = k_0 - \frac{V_{tun}^2}{2}\frac{d^2C(x)}{dx^2}$$

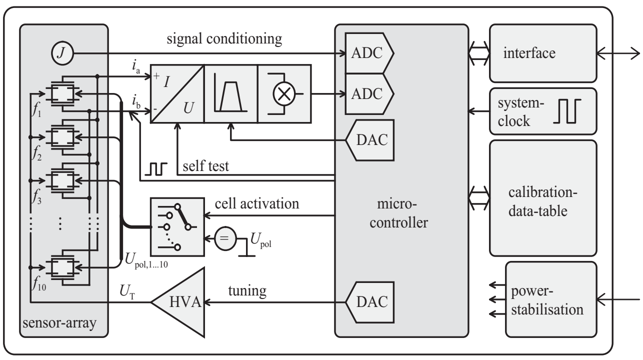
a)



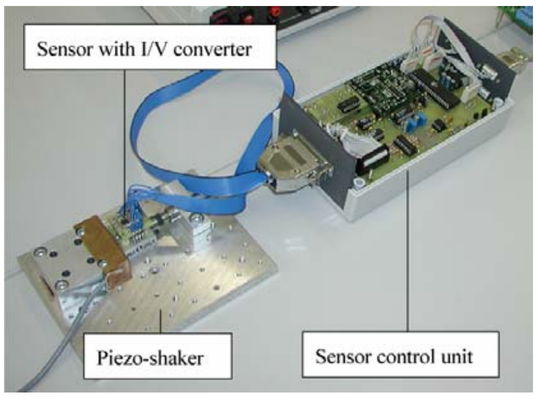
b)

Fig. 2 Sensor-Structure a) Resonance tuning by electrostatic softening b) Fabricated sensor-array

Completed with appropriate packaging, signal conditioning and array control circuitry, such a frequency selective sensor system will be an alternative to wide-band transducers in various applications (fig.3).



a)



b)

Fig. 3 Measurement system a) Schematic overview b) Demonstration setup