THEORETICAL ANALYSIS OF ACOUSTICAL MICROSENSORS RESPONSE IN NANOBIOLOGY APPLICATIONS

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We present new results in physical analysis of acoustical SAW- based (Love- wave) resonators and magnetoelastic microsensors in biofluidic applications where the negligible amount of biomolecular material can be monitored *in situ* in a liquid phase. We reported the exact solution of the dispersion equation of surface acoustic waves (SAW) of Love type for the first type of resonators and demonstrate the importance of size effects in magnetoelastic resonators never taken into account before in such systems. Our results can readily be applied to the correct interpretation of resonance frequency and quality factor changes measured in various biofluidic applications.

Our choice of the resonators has been motivated by the following. SAW-based microsensors operate at high frequency (up to GHz) which is a great benefit for monitoring of mass since the measurable signal, the shift in phase velocity $\Delta V/V$, is $\sim\omega^2$. The Love wave polarization corresponds to the no-slip conditions for example, when the biomolecular coating material is covalently bound to the substrate. Magnetoelastic sensors is a type of acoustic resonance devices considered as the magnetic analog of SAW sensors. Besides of simple design, miniaturization and low cost of the magnetoelastic materials, the advantage of magnetoelastic resonators is a possibility of wireless remote measurements [1,2]. Their working principle is based on a usage of magnetostrictive ribbon-shaped elements of a few mm in size as transducers that mechanically oscillate at a fundamental frequency f_0 when placed in *ac* magnetic field. Viscous- or mass loads cause a variation in the resonance frequency $\Delta f = f - f_0$ of the resonator. Simultaneous monitoring of the dissipation factor $D \equiv 1/Q$ allows to measure fluid viscosity [1]. Both characteristics can be measured with high precision comparable with the SAW sensors. Since polymer coated magnetoelastic resonators are used for biosensors operating mainly in fluids [3,4], it is a crucial to connect the material parameters of coating and biofluid with the experimentally accessible damping coefficient and resonance frequency shifts of the oscillator. Another physical phenomenon that can influence these characteristics is the size effect due to the specific geometry of the resonator. In the present work we take into account both these effects by studying the dynamics of coated resonators oscillating in a longitudinal mode and immersed in biofluid. Comparison of our results with other types of microsensors such as bulk acoustic waves (BAW) devices and thin-film bulk resonators in nanobiology applications [5] is presented as a short survey.

References

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