Application of the electromagnetic piezoelectric acustic sensor (EMPAS) technique in electrochemistry

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The electromagnetic piezoelectric acoustic sensor technique (EMPAS)[1] can be considered a variation of the quartz crystal microbalance in which a bare quartz crystal disk as sensing element is places on top of a planar inductive coil instead of applying it as the dielectric material of a planar condenser. The resonances of the quartz disk will appear in the impedance of the planar coil. There are two advantages of the technique, namely adsorption processes on the top of the bare quartz surface can be studied and resonant frequencies up to 1 GHZ can be detected. Since resonances at different frequencies penetrate into different depth of the adsorbed layer measurements in a wide overtone range permit a deeper look into the structure of the adsorbed layer. The method is based on a high-frequency perturbation through a planar coil which is placed under the bare quartz crystal as close as possible. The high-frequency signal is stepped around the investigated resonant frequency while it is frequency modulated with an audio-frequency signal at the same time. The response signal will contain also an amplitude modulated component corresponding to the audio-frequency signal. After demodulation the change of the audio-frequency signal permits the determination of the actual value of the resonant frequency which depends on the adsorbed mass on the surface of the quartz crystal. As a development[2], in addition to the fundamental frequency of the demodulated audio-frequency signal, we measured also the 2nd, 3rd and 4th harmonics as well allowing the determination of the quality factor of the corresponding resonance.
Even though the technique was originally developed for electrodeless quartz crystal, we tested the technique in electrochemical application as well. In this case the top of the sensing quartz disk (opposite to the planar coil) is covered with a gold layer serving as electrode. We could detect resonances of a quartz crystal with 5 MHz fundamental frequency up to 1 GHZ even in this configuration.

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References

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