

# Combined atomic force microscope and acoustic wave devices: application to electrodeposition.

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We here present the development of an instrument based on a new combination of techniques including scanning probe microscopy (atomic force microscopy, AFM, in our case) and acoustic wave devices (quartz crystal microbalance - QCM - and acoustic wave resonators). We display the ways these two measurement techniques interact and show that their performances are not degraded through interaction. Using finite element analysis, we explain observations compatible with the generation of longitudinal acoustic waves in the liquid, creating standing wave patterns between the QCM sensing electrode and the AFM cantilever holder leading to resonance frequency instabilities of the QCM. QCM electrode vibration in liquid is also shown not to degrade AFM lateral resolution.

We then show measurement results from electrodeposition of copper and silver on gold electrode obtained using this instrument, and demonstrate how the data from both techniques (QCM-D and AFM) are complementary. Since QCM-D allows simultaneous measurement of the resonance frequency at several overtones of the quartz crystal resonator as well as the dissipation (quality factor) of each of these overtones, we show how the relative frequency shifts of the overtones informs on the kind of interactions between the oscillating acoustic wave device and the surrounding media (electrodeposited layer and solution used for electrochemistry). This combined measurement was performed on AT-cut quartz resonators (QCM), SH-SAW lithium tantalate and quartz acoustic wave devices and Love mode quartz acoustic wave devices.

Finally, we show that after identifying the types of interactions we can efficiently use electrodeposition as a mean of calibrating the sensitivity of acoustic wave devices. Sensitivities close to the theoretical values and compatible with previous values given in the literature are presented.