Influence of electrical extensions in AlN BAW resonator response for in-liquid biosensors

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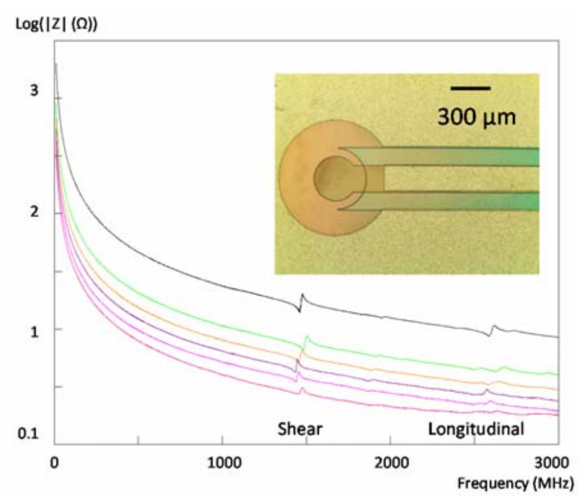
During the last years, the scientific community has shown an increasing interest for acoustic resonators operating in the shear mode for in-liquid biosensing. To feed the liquids onto the resonator a microfluidic system has to be used. This constrains the design of the layout of the resonator to avoid the electrical contacts to be into the liquid, which usually presents a very high ionic character. In some solutions for this problem, the resonators are suspended on a membrane (film bulk acoustic resonators, FBAR) and the fluidic system is implemented on the opposite face of the device where the electrical contacts are. However, if solidly mounted resonators (SMR) are to be used, the active zone in contact with the liquid has to be in the same face of the electrical contacts, which means that these contacts have to be extended in order to spare space for the fluidic system. The targeted resonant frequencies of these devices lie on the 1 GHz to 2 GHz range. At these frequencies, the effects of metal tracks hundreds microns-long are not negligible. The geometry of the lines, the thicknesses of the layers and the properties of the substrate are some of the parameters that strongly influence the added parasitic effects of the electrical extension to the device response. To minimize these effects and to quantify them for designing the electronic circuitry for the resonator excitation, a careful modeling of the electrical extension is needed.

The simulation of the electrical response of the resonators with electrical extensions of their electrodes has been carried out by finite element modeling (FEM) in Ansys-HFSS platform. The geometry, the acoustic reflector layout (either fully insulator or metal/insulator approaches), and the thicknesses of the layers have been considered in the simulations. Test devices for validating the results have been fabricated and measured. Bragg acoustic mirrors made of SiO_2/Mo or SiO_2/Ta_2O_5 stacks have been tested. On top of them, piezoelectric stacks made of tilted-grain AlN films for shear mode operation have been deposited between bottom Ir and top Au electrodes. Resonators with different geometries were simulated, fabricated, and characterized.



Electrical response of resonators with electrical extensions with in the 150 µm-2 mm range built on top of conducting Bragg mirror. The inset is an optical microscopy photograph of one of the test devices

The major effect of the electrical extension of the electrodes is a parasitic parallel capacitance as can be seen in the figure. To minimize it the central top electrode has to be as narrow as possible, though this has a detrimental effect on the series resistance, which could be diminished by increasing the metal layer thickness outside the active area. The use of all-insulating Bragg mirrors and high resistivity substrates makes the parasitic effects to be less influencing.