Aluminum Nitride MEMS FBAR with Integrated Microfluidic Channel

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Objective

Microelectromechanical system (MEMS) film bulk acoustic resonators (FBAR) operating in a liquid environment will be a useful tool for biological/biochemical screening and diagnosis applications. Such applications use molecular probes that capture target molecules, which are subsequently detected by mass-induced FBAR resonant frequency shifts. FBARs operating in air/vacuum environments trap acoustic waves within the device, thereby achieving high Q and highly sensitive mass detection. Operating FBARs in liquid environments drastically reduces Q by a factor of more than 100, due to acoustic energy dissipation in the liquid. This work aims to overcome the limitations imposed by the liquid environment by integrating a microfluidic channel directly on a MEMS L-FBAR, thereby achieving high Q and improving liquid environment detection limits. If successful, portable analyzers could be fabricated from arrays of AlN-based MEMS FBARs using parallel biomolecular detection of target molecules.

Aluminum Nitride

High quality aluminum nitride (AlN) will be used as the piezoelectric material due to its proven CMOS compatibility, which allows truly chip-scale biochemical detectors to be fabricated. AlN can readily be reactively sputtered from an aluminum target in a nitrogen ambient. The piezoelectric properties of uniaxially-textured polycrystalline AlN approach that of single-crystal AlN provided the full-width-at-half-maximum (FWHM) of the x-ray rocking curve is less than a few degrees. The rocking curve FWHM is mainly governed by the initial surface roughness of the substrate.

Longitudinal-mode FBAR

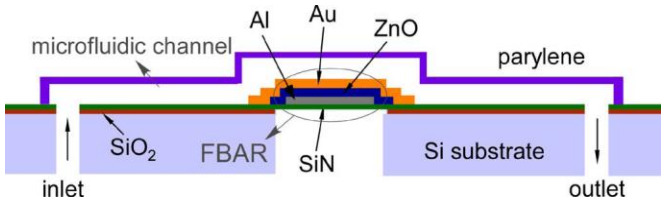
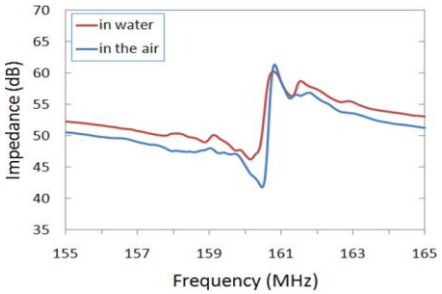


Figure 1. Cross-section of longitudinal-mode FBAR with integrated parylene microchannel (Xu et al., IEEE Electr Device L, Vol. 30, No. 6, 2009).



Compared to contour-mode FBARs, longitudinal-mode FBARs with integrated microchannels offer the advantage of increased sensitivity, continuous flow, and real time reaction monitoring, distinct advantages for biological and chemical analysis.

Figure 2. Impedance spectrum for a typical C-FBAR using commercially sputtered AlN thin film (Tegal Corp). Q values in air and water were 317 and 189, respectively (Xu, Choi, and Chae, Appl Phys Lett, **96**, 2010).

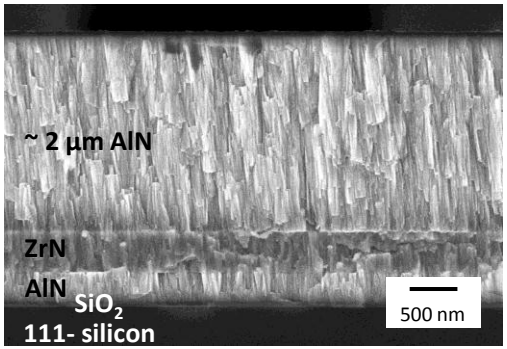


Figure 3. Cross-section FESEM image of as-is deposited AlN/ZrN/AlN stack prior to FBAR processing.

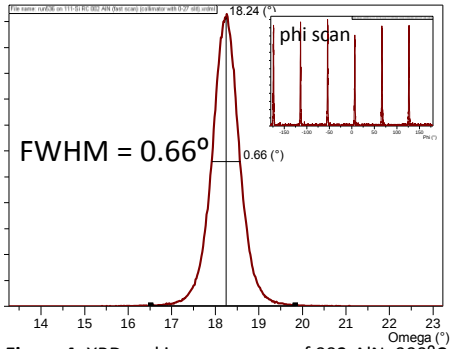


Figure 4. XRD rocking curve scan of 002-AlN. 900°C substrate temperature produces high quality AlN.

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