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Fabrication and performance analysis of air gap type thin film bulk acoustic wave resonator

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Film bulk acoustic wave resonator (FBAR) is a potentially very promising component for filters in the GHz range. Limitations of conventional surface acoustic wave (SAW) resonators are difficulties in on-chip implementation, poor electrical power handling capability and limited frequency-range characteristics. Compared to SAW, FBAR has many advantages. FBAR has a high quality factor (Q) that leads to low loss and high power durability particularly in the radio frequency range. Furthermore, it can be integrated on a silicon substrate. FBAR is composed of a piezoelectric layer (AlN) sandwiched between top and bottom electrodes (Mo) on a silicon wafer. In order to fabricate high performance FBAR, high effective electromechanical coupling coefficient (K_{eff}^2) of AlN films is needed. K_{eff}^2 depends on the degree of c-axis preferred orientation of the films. Therefore, full-width half maximum (FWHM) value of the AlN films' rocking curve should be minimized.

The AlN films were deposited by RF magnetron sputtering on Mo electrode. Microstructure of the films was observed with scanning electron microscopy (SEM) and atomic force microscopy (AFM), and X-ray diffraction (XRD). For low acoustic loss, bottom electrodes should contact with air or vacuum. Hence air-gap structure of stacked electrode and piezoelectric layers was adopted. Silicon and sacrificial layer (SiO_2) below the bottom electrode was removed using deep silicon etching process and wet etching with buffered oxide etchant (BOE). The characteristics of the fabricated FBAR were measured with network analyzer (HP 8753E) from 1700 MHz to 2300 MHz frequency range.