P3K-1

FABRICATION AND CHARACTERISTICS OF AIR-GAP TYPE BAW RESONATOR
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Due to the expansion of the mobile communication market, there are great requirements of wireless communication components such as filters, oscillators, and dielectric filters have been extensively studied for a long time. However, these kinds of devices faced limitation for their applications since they could not be operated in a range of GHz. On the other hand bulk acoustic wave (BAW) resonator has many advantages in miniaturization, mass production, high quality, especially monolithic microwave integrated circuit (MMIC). An air-gap type BAW resonator was composed of Al film for the bottom and top electrodes, ZnO film for the piezoelectric layer, Al film for the sacrificial layer, and Si for the substrate. And To improve the mechanical properties of a membrane layer, membrane supporting layer formed by spin-on glass (SOG) was applied for the first time. Al and ZnO films were deposited by DC and RF magnetron sputtering method, respectively. It is important to control the thickness of the electrodes and the piezoelectric layer equal to a quarter and a half wavelength of acoustic wave. Patterns of each layer were made by basic semiconductor processes. Finally the resonant properties of the air-gap type BAW resonator devices were measured by using Cascade Summit 9000 probing station, Cascade GSG-150 probes, and Agilent E8364A network analyzer. As a result, it was shown that SiO2/SOG membrane layer had good mechanical properties to support the resonant area on itself and the resonator showed good frequency characteristics.

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P3K-2

TEMPERATURE CHARACTERISTICS OF SOLIDLY MOUNTED PIEZOELECTRIC THIN FILM RESONATORS
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SMR (Solidly Mounted Resonator) -type piezoelectric thin film resonators, which are consisting of a piezoelectric film on alternately laminated low- and high-acoustic-impedance quarter-wave layers (multilayers) on a substrate, are now receiving attention as bulk acoustic wave devices suitable for use in a super-high-frequency range. For practical applications, however, the temperature dependence of frequency is desirable to be very low. In 1981, Nakamura et al. [1] reported that a vanishing TCF (Temperature Coefficient of Frequency) can be achieved in a ZnO/SiO$_2$ FBAR (Film Bulk Acoustic Resonator), because both materials have a TCD (Temperature Coefficient of Delay) opposite to each other in sign.

This paper reports the theoretical analysis on the temperature characteristics of the SMR using ZnO as the piezoelectric film, SiO$_2$ as the low impedance $\lambda/4$ layer, and ZnO as the high impedance layer. The calculated results on the total layer number dependence of TCF show that the absolute value of TCF decreases with increasing the total layer number and approaches about 27 ppm/$^\circ$C. This improvement of TCF is due to the negative TCD of SiO$_2$ layers as in the case of the ZnO/SiO$_2$ FBAR. It is also shown that the temperature compensation of the SMR can be achieved by changing the thickness of the first $\lambda/4$ SiO$_2$ layer just below the piezoelectric film or by depositing a SiO$_2$ layer on the piezoelectric film, although the effective electromechanical coupling factor $K^2$ and $Q$ decrease a little. Similar theoretical analyses on the SMRs using ZnO or AlN as the piezoelectric film material and Mo or AlN as the high impedance layer material are reported. Experimental results will also be presented to prove the calculated results.

References.

P3K-3

PREPARATION OF AZO/ZNO/AZO/SIO$_2$/SI THIN FILM FOR FBAR


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ZnO thin films for Film Bulk Acoustic Resonator (FBAR) were prepared by FTS (Facing Target Sputtering) system. The FTS method enables to generate high density plasma, high deposition rate at low working gas pressure and high quality thin films preparation. In this study, in order improve the crystallographic properties of ZnO thin films, AZO(ZnO:Al : Al$_2$O$_3$ (2wt:2%)) bottom electrode that have equal crystal structure of ZnO thin film, were deposited on SiO$_2$/Si substrate. And, ZnO thin film were deposition with oxygen gas flow ratio and variety of substrate temperature at 2mTorr discharge gas pressure, sputtering current 0.8A. Film thickness and c-axis preferred orientation of ZnO thin film
were evaluated by a-step and XRD. Also, we measured $k_{2\text{eff}}$ as a function of resonance area of ZnO:Al electrode using Network analyzer.

**P3K-4**

**CRYSTALLOGRAPHIC PROPERTIES AND EFFECTIVE ELECTROMECHANICAL COUPLING COEFFICIENT OF ALN THIN FILM WITH SUBSTRATE TEMPERATURE**

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AlN thin films for FBAR (Film Bulk Acoustic Resonator) device prepared by FTS (Facing Targets sputtering system) with a DC power supply which provides a stable discharge at low gas pressure and can deposit a high quality thin films because of the substrate located apart from plasma. In the study crystallographic characteristics and effective electromechanical coupling coefficient ($K_{2\text{eff}}$) of AlN thin films were investigated as a function of $N_2$ gas flow ratio [$N_2/(N_2+Ar)$] and the substrate temperature, 0.9?0.6 and R.T.?300, respectively. The AlN thin films were deposited on a slide glass and a SiO$_2$/Si substrate using an Al bottom(thickness of 200nm) and top(thickness of 200nm) electrode. The process parameters such as sputtering power, working pressure were fixed at 200W and 1mTorr, respectively. Thickness of AlN thin films was measured by a-step. The crystallographic characteristics, c-axis preferred orientations and effective electromechanical coupling coefficient ($K_{2\text{eff}}$) of AlN thin films were evaluated by XRD and Network analyzer, respectively.

**Session: P3L**

**THIN FILM BAW: MATERIALS AND RESONATORS II**

Chair: J. Larson
Agilent

**P3L-1**

**DEPENDENCE OF THE ELECTROMECHANICAL COUPLING ON THE DEGREE OF ORIENTATION OF C-TEXTURED THIN ALN FILMS**

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Highly c-oriented thin AlN films have been grown at room temperature with reactive sputter deposition. Membrane FBAR thickness excited resonators have been subsequently fabricated by bulk micromachining of Si. Both the top and the