Reconfigurable Film Bulk Acoustic Wave Resonator (FBAR) using Magnetostrictive Thin Films

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Background, Motivation and Objective

We have realized a magnetic field reconfigurable Film Bulk Acoustic Wave Resonator (TFBAR) using magnetostrictive $Fe_{65}Co_{35}$ thin films. The resonator acoustic layer stack consists of $Si/SiO_2/Pt/ZnO/Fe_{65}Co_{35}$ multilayers for tuning of devices. Due to ΔE effect, TFBAR resonance frequency was up-shifted 106.875 MHz (4.91%) in presence of 2kOe magnetic field. From experimental measurement, ΔE enhancement was estimated to be ~35.06 GPa. Further, it is observed that return loss (S_{11}), phase response and quality factor was improved in presence of magnetic field due to high stiffness. Equivalent Modified Butterworth-Van Dyke (mBVD) circuit model was developed and fitted with experimental data and circuit parameters are extracted. The proposed resonator is small size, low loss, power efficient and usable at higher power levels. This method facilitates a new way of tuning FBAR devices using magnetostrictive thin films.

Statement of Contribution/Methods

Film bulk acoustic wave resonator tuning based on magnetostrictive films is rarely investigated. Here, we report new method of tuning FBAR devices using magnetostrictive $Fe_{65}Co_{35}$ thin films. $Fe_{65}Co_{35}$ thin films show high magnetostrictive coefficient and film Young's modulus can be changed by applied magnetic field. Magnetostrictive $Fe_{65}Co_{35}$ layer is incorporated in FBAR device for proposed functionality. When TFBAR is placed in magnetic field, tuning was 4.91%, which is very high compared to other tuning methods.

Results/Discussion

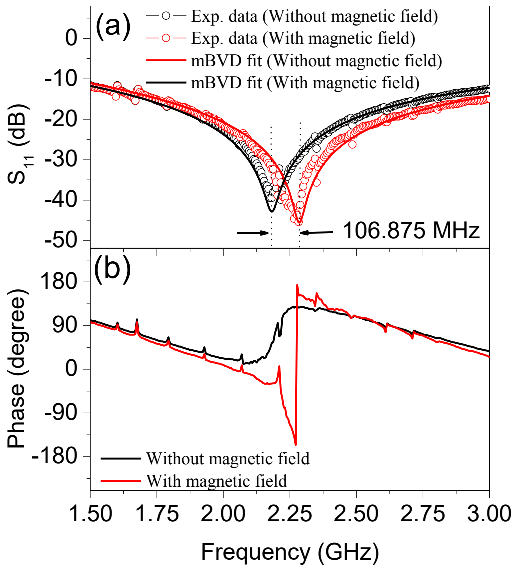

Figure 1: (a) Insertion loss of TFBAR without magnetic field and with magnetic field and (b) Phase response of resonator without magnetic field and with magnetic field.

Scattering parameter (S_{11}) of resonator was measured using a vector network analyzer as shown in Figure 1(a). Excitation frequency was sweep in the 1.5 - 3.0 GHz range and resonance peak position was noted. Initially, when there was no magnetic field present, resonance was observed at 2.176 GHz and return loss was -39.5 dB. Quality factor was estimated using 3dB bandwidth method and found to be 64.48 in absence of magnetic field. Correspondingly, phase response was measured and observed that phase change at resonance as shown in Fig.1(b). Now, resonator was placed in dc magnetic field (2kG) and return loss response was measured. It is perceived that resonance frequency was up-shifted to 2.283 GHz and return loss was improved to -45.4 dB. This measured frequency shift was 106.875 MHz and 4.91% of resonance frequency.