32.8°Y-$LiNbO_3$ Thin Film Grown by DLI-CVD for High-Frequency Bulk Acoustic Resonators

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Background, Motivation and Objective

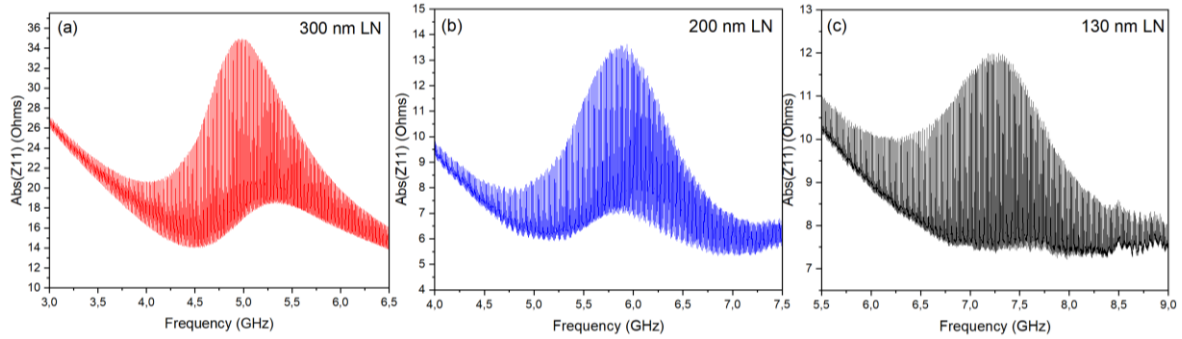
The next generation of radio-frequency (RF) telecom applications urgently requires filters operating at frequencies above 3 GHz, particularly operating in the C-Band (4–6 GHz). $LiNbO_3$ (LN) films were identified as one of the materials with sufficient electromechanical coupling, K^2, for these applications [1]. *To achieve 6-9 GHz frequencies in bulk acoustic wave (BAW) devices, LN films thickness has to be below 200 nm, therefore their fabrication by top-down methods (polishing or ion slicing process) remains challenging. This motivates further development of integration of deposited highly-coupled LN films with BAW resonators. Thin-film bulk acoustic wave resonator (FBAR) based on c-axis oriented $LiNbO_3$ thin films deposited by chemical vapor deposition (CVD) attaining k_t^2 of 5.8% has been reported* [2]. *To achieve higher electromechanical coupling factor different orientations of $LiNbO_3$ should be grown. This work reports the fabrication of high-overtone bulk acoustic wave resonators (HBAR) using 32.8°Y-X highly-coupled LN films deposited by direct liquid injection (DLI-CVD).*

Statement of Contribution/Methods

In this work, 120 nm thick (111) textured Pt layers and 30 nm thick $(01\bar{1}2)$ textured $LaNiO_3$ seed layers were deposited by magnetron sputtering on 4'' sapphire. The patterning of the Pt-bottom electrode was performed by means of RIE (reactive ion etching). Then, 120-330 nm thick LN layers with nearly congruent Li composition (measured by Raman spectroscopy) were deposited by means of DLI-CVD. Al top electrodes with thickness of 100 nm were structured by standard lift-off process. Finally, RIE was used to etch LN layer to access Pt bottom. Frequency response of the fabricated resonators was characterized by using a Vector Network Analyzer.

Results/Discussion

The fabricated HBAR heterostucture had sharp interfaces showing good chemical stability of the layers. The $LiNbO_3$ layers were dense and show no defaults. The X-ray diffraction has confirmed pure textured growth of $(01\bar{1}2)$ LN films [3], *which corresponds to (YXl)/32.8° in IEEE convention. The resonance frequencies of HBARs based on LN films with different thickness were in the 4.5 GHz -7.3 GHz range (Fig. a-c) and the measured responses were in a good agreement with simulations done by using LN single crystal properties. However, further design optimization is needed to ameliorate impedance matching. 32.8°YLN/$LaNiO_3$ layers can be implemented on any substrate and heterostructure including mirrors or sacrificial layers, which are able to withstand high-temperature and atmosphere of LN film deposition and induces acceptable thermal stresses.*



[1] *Adv. Mater. Interfaces*, vol. 4, no. 8, p. 1600998, Apr. 2017.
[2] *IEEE International Ultrasonics Symposium*, Oct. 2010, pp. 91–94.
[3] *Patent EP20 305575*