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Power Handling Considerations in XBAR Acoustic Wave Filters

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Background, Motivation and Objective

Recently we presented laterally e**X**cited **B**ulk **A**coustic **R**esonators (XBARs) based on thin (0.4 µm) monocrystalline layers of ZY-cut $LiNbO_3$ (LN) [1]. XBAR resonators are simple, highly engineerable, and can achieve both the high frequency and large bandwidth necessary for filters in future 5G bands. Beyond the small signal regime, we discuss the power handling capabilities of the already described XBAR resonator structures. We will then discuss several modifications of the XBAR structure, IDT dimensions, and metal stack, to obtain superior power handling necessary for 5G applications. Finally, we discuss the non-linear performance of these devices in terms of the harmonic H2 and H3 excitations and intermodulation distortion (IMD).

Statement of Contribution/Methods

For filter simulation and studying the distribution of acoustic and electric fields in devices, we use our 2D FEM software [2] and Infinite Synthesized Networks (ISN) design environment. Electromagnetic simulation of the filter layouts is done using commercial software. We model the thermal performance of our filters during the design process using our integrated self-consistent FEM method, informed by infrared microscope imagery. Finally, we present measured data for the power handling performance of fabricated filters showing reasonable quantitative agreement with models (see Figures below).

Results/Discussion

We present an XBAR filter with demonstrated 1W power handling and report on methods for improving heat flow. In the original XBAR concept, the suspended monocrystalline LN membrane is a poor thermal conductor and limits the thermal performance of the device. In addition, while low IDT metal duty factors are ideal from an acoustic loss perspective, they restrict heat flow out of this thermally insulating LN membrane. We therefore identify a viable alternate IDT metal stack with high Q and minimal spurious content which effectively improves thermal conductance to ground. We further demonstrate that ability of this metal stack to handle larger duty factors with minimal spurious distortion and loss which further increases thermal conduction from the original minimal duty factor XBAR approach. Simulations suggest that these design techniques can combine to give in excess of 6 dB in equal-temperature performance improvement as compared to designs which are not optimized for thermal performance. We will report experimental tests of these design techniques in our final paper. We also present data of harmonic excitations and IMD performance and demonstrate performance comparable to existing technologies applicable for use in 5G applications. Finally, we consider solidly mounted resonator (SMR) configurations and propose potential alternative geometries to suspended membranes.

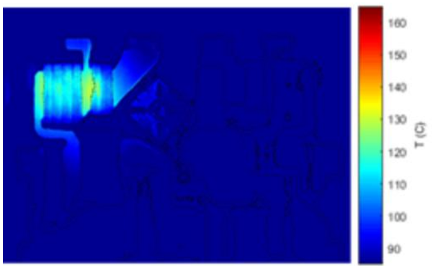

Figure 1: Measured filter temperature map

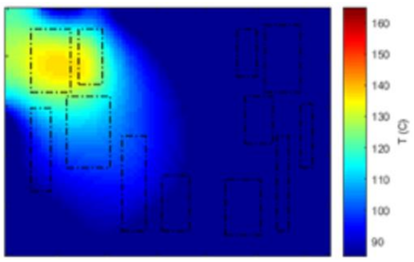

Figure 2: Simulated filter temperature map

[1] V. Plessky, et al. Electronics Letters 55.2 (2018), pp. 98-100.
[2] Koskela, Julius, et al. "Hierarchical Cascading Algorithm for 2-D FEM Simulation of Finite SAW Devices." IEEE transactions on Ultrasonics, Ferroelectrics, and Frequency Control 65.10 (2018): 1933-1942.