Surface Cavity Wave Structures for Ultra-Compact Radio Frequency Filters.

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Summary—We present a Surface Cavity Wave filter (SCAW). It is an acoustic filter presenting multiple poles due to multiple-coupled cavities between transducers. We have a compact filters (as DMS) but achieve a shape factor and insertion loss at the level of ladder filters.

Keywords—Surface Cavity Wave filter (SCAW) ,Multiple cavities, Piezo-On-Insulator,Compactness, Low loss, Shape factor

I. Introduction

The development of new generations of telecommunication wearable setups requires more and more front-end devices and modules. RF communication requires multiple bands and data rate capabilities on line with the consumer demands. The trend is thus to increase the compactness of the filters.

To achieve this goal, we present a new filter architecture using Surface Cavity Acoustic Wave (SCAW)[1]. The filter consists of resonant acoustic cavities placed in between at least two transducers (Fig1). This architecture allows for achieving narrow (~0.1%) and wide (~5%) bandpass filters using the same substrate. This provides to the designer many possibilities for designing various types of filters at various frequencies.

For SCAW large band filters, we need a large coupling (1,5 times the fractional bandwidth) and an even larger reflection coefficient (2 times the fractional bandwidth). All those conditions can be gathered by using guided waves. The latter can be generated by a sub-wavelength thick piezoelectric material bonded on various materials providing the confinement of the wave. With a proper choice of underlying layers, the waves can exhibit a coupling coefficient and a reflection coefficient larger than piezoelectric bulk materials and no radiation into the bulk. This stack can be achieved with the so-called Smart-Cut™ technology, yielding Piezo-On-Insulator (POI) substrates. Combining SCAW structures onto POI yields ultra-compact filters with either narrow or large bandwidths. Nonetheless, SCAW can also be achieved on bulk material ($LiNbO_3$ Y+128 for instance) when the reflection coefficient is large enough.

II. SCAW Principles/Experimental Results

In this contribution, we will first present in detail the SCAW architecture (see figure [1]). Secondly, we will show experimental results of filters when only the number of coupling mirrors is changed (see figure [2]) to illustrate the effect on the transmission function of poles addition. In Addition, finite SCAW FEM/BEM and mixed-matrix-based filter simulations will be added and confront to experimental results. In the third part, we are going to focus on experimental results of a SCAW design at 1.92GHz with a -3dB 3.1 % fractional bandwidth, see figure [3]. It presents a 1.3dB standard insertion loss and a 13 ns group delay variation between the central frequency and the -3dB bandpass edges. Return loss over the whole -1dB bandpass is near 15dB. The phase is almost linear in the bandpass. Increasing number of poles by adding cavities allows for a shape factor (BW-40dB/BW-1dB) of 1.93 and a roll-off taking advantage of intrinsic POI qualities. We are immune to transverse modes and the POI substrate yields a TCF around 11 ppm/K. The device dimensions (without footprint connections) are 215μmX170μm.

It is worth mentioning the versatility of this structure for the designer. We are able to shape the fractional bandpass easily by changing the coupling between cavities (number of fingers in the coupling mirrors) as well as the transition band (number of cavities). A tradeoff between shape factor, transition band and insertion loss is necessary.

III. Conclusions

With these experimental results, we demonstrate that SCAW filters allow for a compact device (contrarily to ladder filters) without the sacrifice of insertion loss, shape factor and transition band. The insertion loss is actually found at 1.3dB, the group delay variation near 13 ns and the shape factor at 40 dB is around 1.93. The TCF without any passivation layer is close to 11 ppm/K.

Design with insertion loss around 0.8-1dB and sidelobe rejection increased to 40 dB will be soon diclosed to the community.

References

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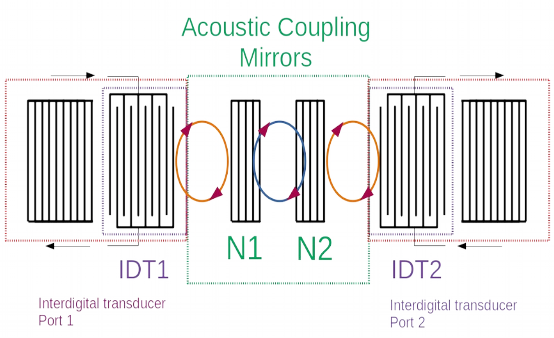

Figure 1: Principle scheme of a SAW filter.

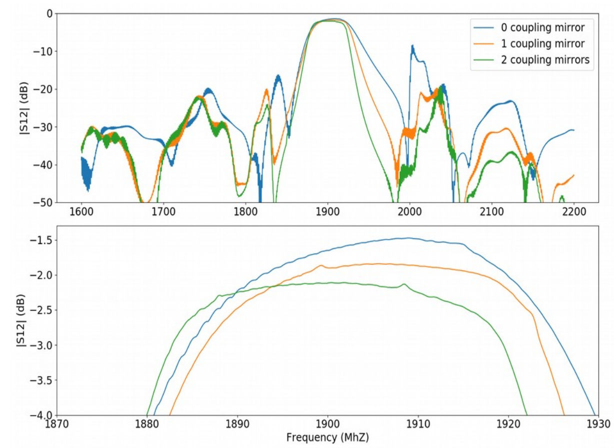

Figure 2: Effect on the shape factor and transition band with addition of acoustic cavities.

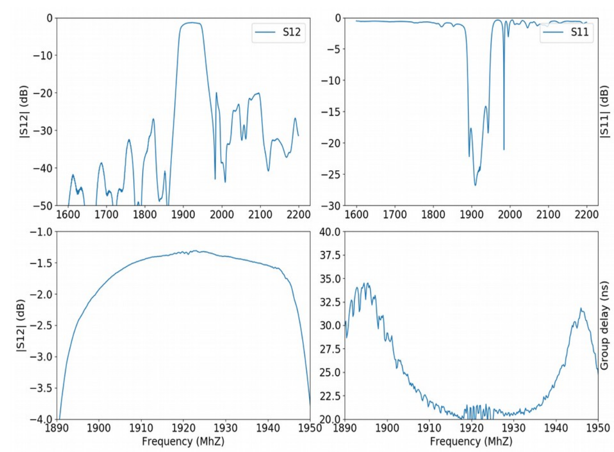

Figure 3: SCAW filter: Central frequency ~1923MHz, 3.1% -3dB fractional Bandwidth, Insertion loss 1.3dB, 13nS group delay variation.