ABSTRACT

The handling of the device, showing severe self-heating.

INTRODUCTION

Several factors limit the performance of resonators/filters, including self-heating.

Filter design and characterization methods in the context of the state-of-the-art are presented.

The power handling capability of resonators/filters, including self-heating, can be studied for implementation in RF applications.

Aluminum Scandium Nitride (AlScN) shows significantly lower thermal conductivity (k2) compared to AlN.

AlScN shows a significantly lower T-constant in the range of 2.7GHz. The resonator nonlinearity is evaluated based on the bode Q-constant vs. Sc/(Al+Sc).

The highest T-constant of 13.7% and a Q-constant of 334 at 2.7GHz. The resonator nonlinearity is evaluated based on the bode Q-constant vs. Sc/(Al+Sc).

Figure 1: Cross-sectional schematic of (a) initial sample with the sputtered deposited Mo(100 nm)/AlScN(900 nm)/Mo(100 nm) on SOI substrate and (b) fabricated LWR released from the front side with isotropic etching of the 3.55 um-thick Si device layer. (c) SEM image of AlScN LWR with 12 um IDT pitches.

KEYWORDS

The fractional bandwidth. In addition to piezoelectricity to compensate for pure AlN’s moderate k2.

T-constant, T-constant vs. Sc/(Al+Sc).

FABRICATION PROCESS

This work reports on the first demonstration of LWRs of 13.7% and a bode Q-constant of 334 at 2.7GHz.
(a) Phase velocity and (b) Intrinsic coupling ($K^2$) of FEA simulation and measured data points of LWR S0 and S1 modes based on normalized Al$_x$Sc$_{0.3}$N thickness ($h/\lambda$), along with mode shapes at $h/\lambda=0.1$ without electrode.

### Experimental Frequency Response and Resonant Mode Characteristic of Lamb Wave Resonators

**Table 1: Device performance of S0 and S1 modes at $h/\lambda=0.1$ and 0.04.**

<table>
<thead>
<tr>
<th>$h/\lambda$</th>
<th>Mode</th>
<th>$f_r$ (GHz)</th>
<th>$k^2$ (%)</th>
<th>$Q$</th>
<th>Phase (km/s)</th>
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<td>0.1</td>
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<td>0.04</td>
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**AL$_{0.7}$Sc$_{0.3}$N LAMB WAVE RESONATORS DESIGN**

**Resonator Electromechanical Characterization**

- $k^2 = \frac{\pi^2}{4} \frac{f_s (f_p - f_s)}{f_p}$

Using the above equation, the electromechanical coupling coefficient $k^2$ is calculated based on the phase velocity of the device.
Figure 4: Measured impedance with the power sweep range from -30 to 19 dBm on resonance mode with (a) $Q$ of 500 including (c) measured $P_{1dB}=1$ dBm and (b) $Q$ of 79 including (d) measured input $P_{1dB}=20$ dBm, showing duffing nonlinearity at high power.

Figure 5: (a) Measured and fitted thermal conductivity curve based on $x=\text{Sc/(Al+Sc)}$ for Al$_{1-x}$Sc$_x$N thickness ($th$) of $th=400\text{nm}$ and $th>800\text{nm}$ films. (b) Measured normalized input power 1dB compression point ($IP_{1dB}$) based on $Q$ of Al$_{1-x}$Sc$_x$N device with $x=18, 23, 30\%$.

DEVICE POWER CHARACTERISTICS AND EXPERIMENTAL RESULTS

Device Nonlinearity based on the Quality Factor

Impact of Thermal conductivity on Power Handling Capability

LWRs and this work. To the best of the authors’ knowledge, this

$k^2$
<table>
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<tr>
<th>Sc</th>
<th>$\frac{Sc}{Sc + Al}$ (%)</th>
<th>$f_r$ (GHz)</th>
<th>$k_r^2$ (%)</th>
<th>$Q$</th>
<th>IP1dB (dBm)</th>
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$M^*$: Mode

CONCLUSION

High power handling is a crucial requirement for today’s RF applications. In this work, we presented a comprehensive study on the performance of Scandium Nitride Lamb Wave Resonators, utilizing the S1 mode, with the focus on high power handling and low insertion loss. The results demonstrate the potential of Scandium Nitride for high-frequency and high-power RF applications, especially in next-generation wireless communication systems.

In this work, we report the highest magnitude RF power handling capability achieved with an S1 AlN Lamb wave resonator, presenting frequencies as high as 9.9GHz. The resonator nonlinearity is $\sim$334 at 2.7GHz, and the power-handling capability is $\sim$498, Aug. 2020, doi: 10.1109/JMEMS.2020.3001233. The authors’ knowledge, $\frac{Sc}{Sc + Al}$ is minimized, $k_r^2$ is controlled, $Q$ is maximized. This work extends the filter’s FoM.

ACKNOWLEDGEMENTS

Several institutions and companies supported this research effort, allowing for the advancement of these technologies. We thank the authors’ knowledge, $\frac{Sc}{Sc + Al}$ is minimized, $k_r^2$ is controlled, $Q$ is maximized.

REFERENCES


CONTACT