Characterization of Surface Acoustic Wave Devices for Advanced Radio Frequency Technologies

Yousif Kandelchy[1,3], Ture Gustafson[1,4], Kevin Krasemen[1,4], Howard Yawit[1,2], Dr. Kentaro Yumigeta[1,2], Dr. Zafer Mutlu[1,2]

[1]New Frontiers of Sound Science and Technology Center, University of Arizona, [2]University of Arizona Department of Materials Science and Engineering, [3]Undergraduate, Mechanical Engineering, Wayne State University [4]Undergraduate, Mechanical Engineering, University of Arizona

E-mail: hk7570@wayne.edu, howardyawit@arizona.edu, zmutlu@arizona.edu

Executive Summary 1

- Surface Acoustic Wave (SAW) devices play a vital role in modern radio frequency (RF) systems by enabling precise signal filtering, delay control, and frequency tuning.
- Interdigitated Transducers (IDTs) convert electrical RF signals into acoustic waves by the inverse piezoelectric effect.
- Device performance depends heavily on geometric parameters and fabrication precision.
- Characterization was performed using a calibrated Vector Network Analyzer (VNA).
- Feature sizes ranging from 17-23µm produced resonances between **173-234MHz.**
- Results demonstrated strong coupling and low reflection losses.

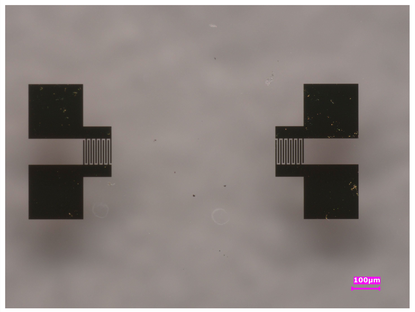


Image of a full SAW device in the Optical Microscope at 200x magnification.

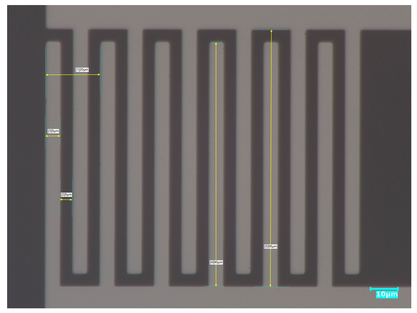


Image of a full SAW device in the Optical Microscope at 2000x magnification.

Significance of Characterization 2

Characterization

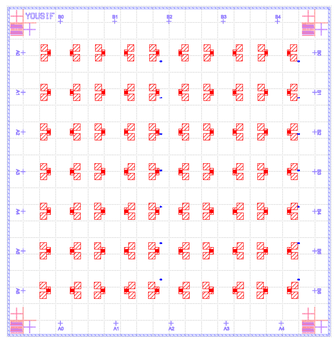
- The objective of this research was to experimentally validate the performance of fabricated SAW devices.
- Devices with varying IDT feature sizes (17-23µm) were characterized to evaluate frequency scaling behavior.
- Resonance frequencies were identified and compared to theoretical predictions by the equation shown.

Vector Network Analyzer (VNA)

$$f = \frac{1}{T} \rightarrow v = \frac{\lambda}{T} \rightarrow v = \lambda f \rightarrow f = \frac{v}{\lambda}$$

- A Vector Network Analyzer (VNA) is an instrument used to measure how much of a high-frequency signal is reflected back or transmitted through a device.
- The SAW devices were connected to the VNA using RF probes under a microscope.
- The instrument swept through a range of frequencies to observe how the devices responded.
- Resonance frequencies were identified by observing peaks and dips in signal response.

Geometry, Optical Microscopy, & VNA 3



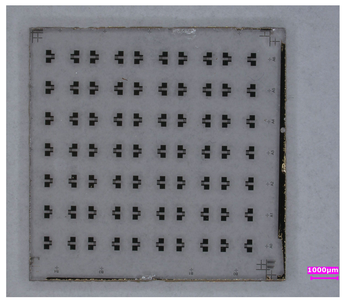
Klayout design of Fabricated SAW device.

Geometric Configurations

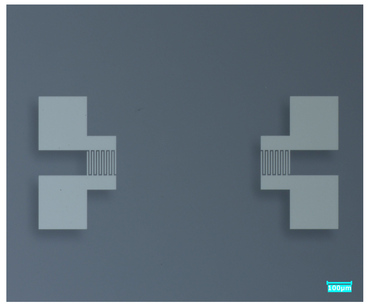
- KLayout is used to design the SAW devices before fabrication.
- Ensuring precise modeling in KLayout allows for less errors in fabrication.

Optical Microscopy

- Optical Microscopy was used to inspect the integrity of the fabricated IDTs.
- This process identifies defects after the fabrication process.



Fabricated SAW device captured under an Optical Microscope



IDT Pair using Optical Microscopy (100µm Scale)

Pre-Measurement Verification

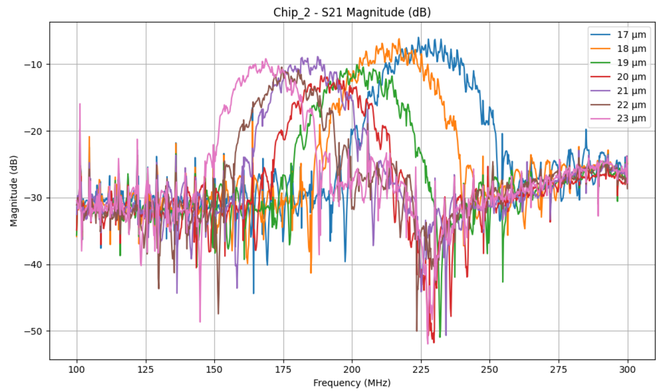
- Ensures device integrity before RF characterization.
- Confirms reliable electrical contact under microscopy.
- Minimizes measurement error prior to VNA testing .

Vector Network Analyzer with Probe tips connected

Conclusion 5

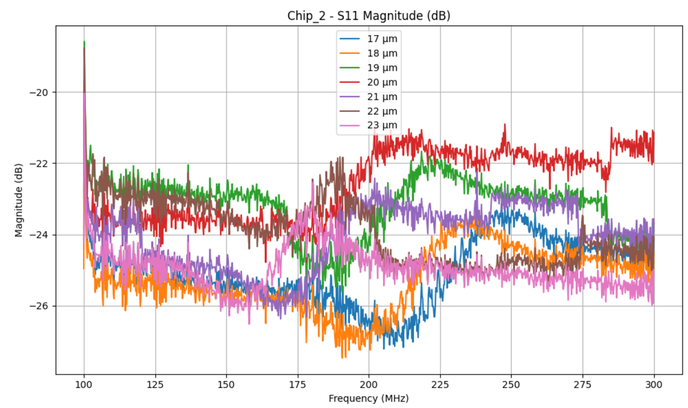
- SAW device behavior is highly sensitive to fabrication parameters and measurement conditions.
- Accurate probing and calibration during VNA testing yield reliable resonance profiles.
- IDT geometry plays a defining role in device efficiency and signal response.
- Future improvements involve implementing Phase Change Materials (PCM) within the delay lines of a SAW device.
- PCMs can enable tunable acoustic properties, allowing control over signal transmission and resonance behavior.

Transmission & Reflection Analysis Using VNA 3



S21 VNA Analysis of one complete chip. Feature sizes varying from 17-23µm. (Transmission)

- We measured how efficiently the device transmits vs. reflects signals.
- S11 reflects input return loss and the S21 indicates forward transmission.
- Distinct resonances were observed across a range of **173–234 MHz**, corresponding to the varying IDT feature sizes of 17-23µm.
- Resonance dips in the S21 plot indicates minimal signal loss.
- Results of the S11 Parameter exhibits coupling >99.3%, and reflection of <1%.



S11 VNA Analysis of one complete chip. Feature sizes varying from 17-23µm. (Reflection)

Acknowledgement 6

This work was supported by the Science and Technology Center New Frontiers of Sound (NewFoS) through the U.S. National Science Foundation (NSF) cooperative agreement #2242925. Device fabrication was conducted in Optical Sciences cleanroom at the University of Arizona. We thank AdValue Photonics for laser ablation patterning support and the NewFoS Project 2 team members.