Integrated Surface Acoustic Wave Device on an Aluminum Nitride Wafer

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Introduction

Surface acoustic wave (SAW) devices are essential for many signal processing applications, ranging from filtering a signal, creating a device for military use, or using them to create a cell phone with better reception. Surface acoustic waves are generated by applying an electric signal to a piezoelectric substrate, which then turns the electric signal into an acoustic wave. SAW devices contain rectangular-looking figures known as interdigital transducers, essential for converting the acoustic wave back into an electric signal at the output. Therefore, two SAW devices are required for this effect to occur. The piezoelectric substrate used in this project is Aluminum Nitride (AlN), which allows the user to send a high frequency to the SAW device and operate at high temperatures.

Fig.1

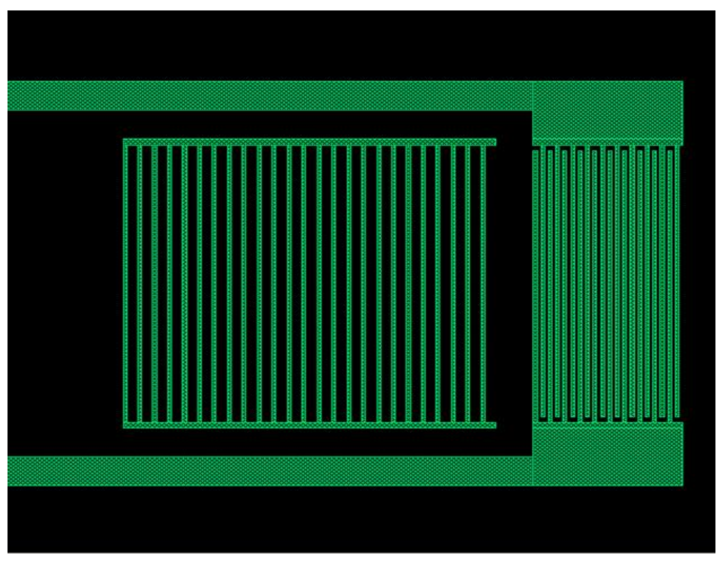
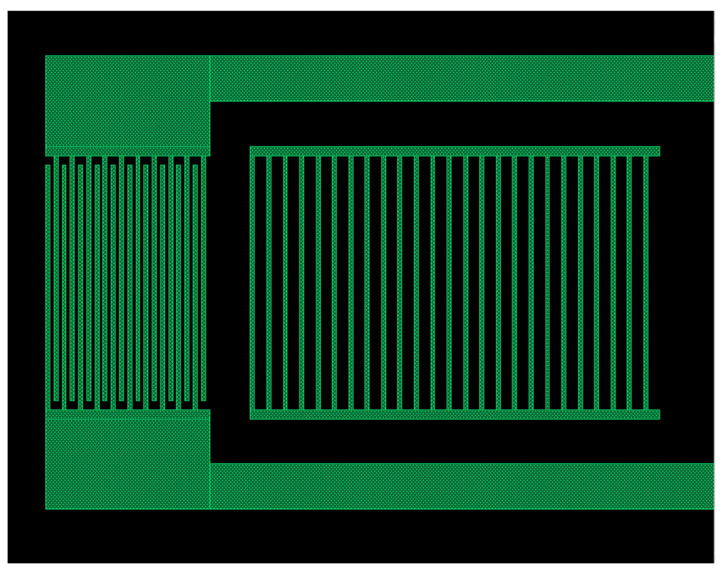


Fig. 2



Figures 1&2 show a close view of each SAW device

Methods

- **Determine wavelength of device using $\lambda = {}^{v}/_{f}$**
  f= 10 GHz; v= 10^4m/s
- **Vary delay line between the multiple SAW devices by 100 µm intervals**
- **The width of figure 1 is 250 µm; the width of figure 2 is 150 µm**
- **Spin coat S1813 photoresist on wafer**
- **Expose UV light for 8 s**
  Develop in MF319 for 20s
- **Deposit ~200µm of Aluminum layer to form electrodes**
- **Design PCB to apply RF signals to SAW device**

Fig. 3

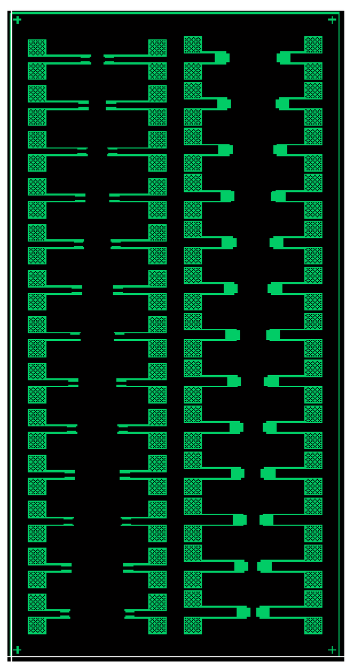


Figure 3 shows two columns of input and output SAW devices with various delay lines. In all, this device was designed on a 1cm x 2cm wafer

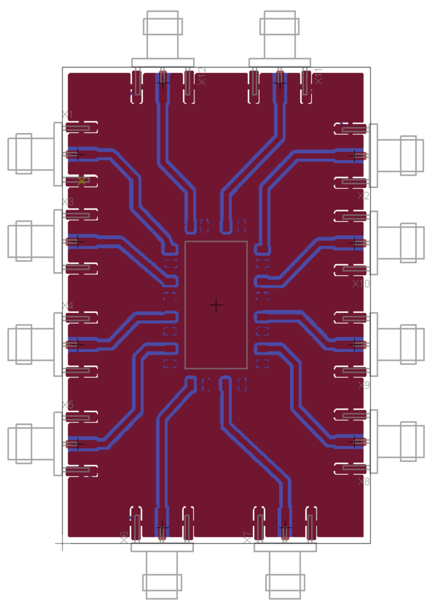


Fig. 4

Figure 4 shows the PCB layout used for testing the SAW device. Fig. 3 is placed in the middle area. The size of the PCB is 2'' x 3''

Results

Fig. 5

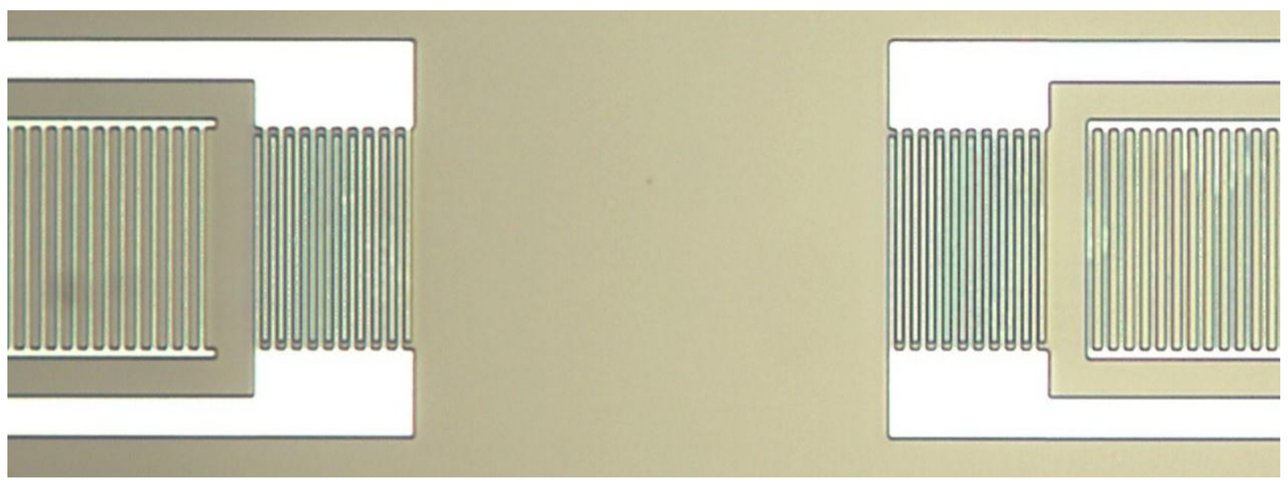


Figure 5 shows a completed SAW device after a 200nm layer of Aluminum was deposited across the surface. The distance between the input and output IDT is known as the delay line.

Fig. 6

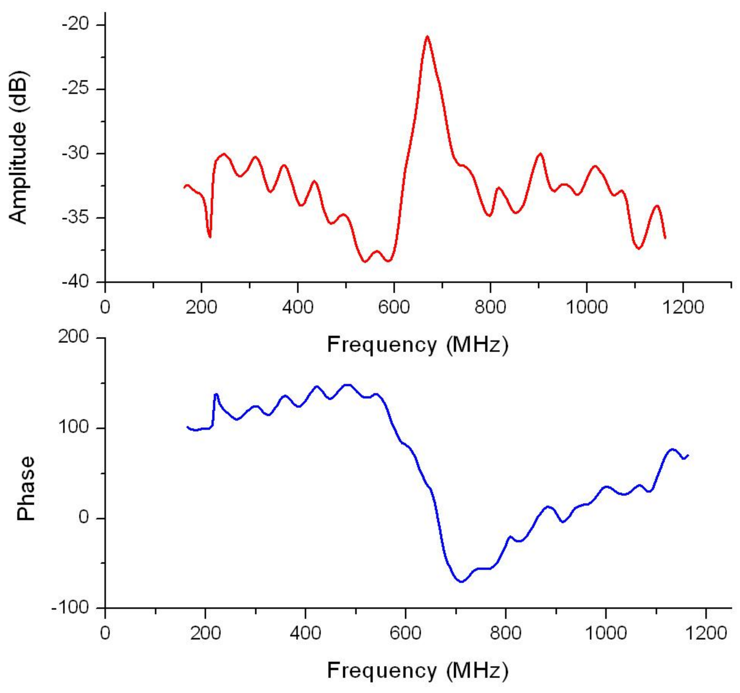


Figure 6 represents the amplitude and the phase of the 250 µm wide SAW device with a 200 µm delay line.

Figure 7 represents the amplitude and the phase of the 250 µm wide SAW device with a 1600 µm delay line.

Fig. 7

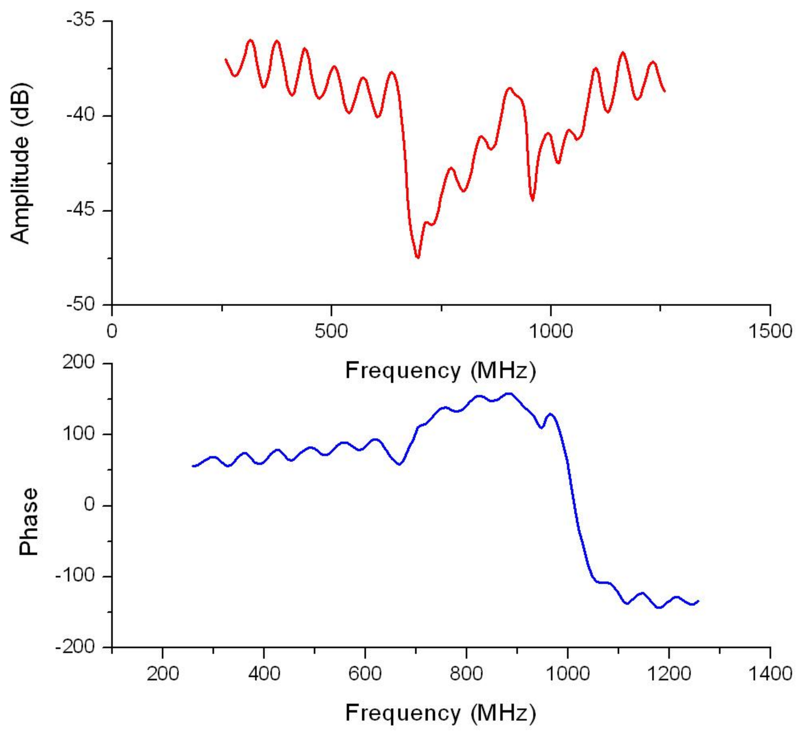


Fig. 8

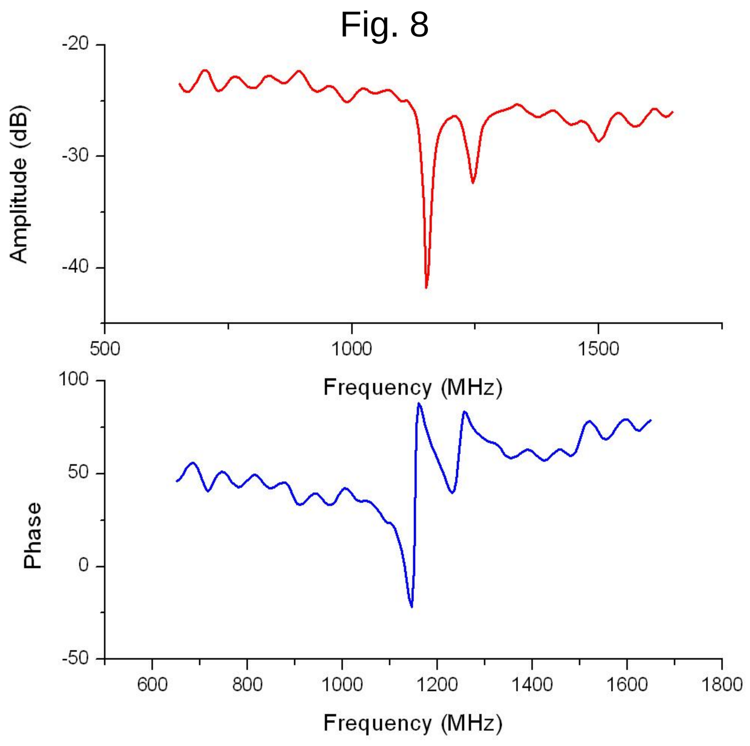


Figure 8 represents the amplitude and the phase of the 150 µm wide SAW device with a 1300 µm delay line.

In theory, this type of setup as viewed in figure 5 is supposed to resonate at the output. Even though figures 6, 7, and 8 do have ripples in their amplitude, this is still not ideal. They also contain deep downward shifts in their amplitudes, possibly because of insertion loss within the device. As can see, delay lines do affect the behavior of the SAW device. A SAW device with a smaller delay line appears to have a higher amplitude in terms of frequency. A smaller SAW device (as in Fig. 8) does appear to have a smaller phase response. It is essential to remember that one of the benefits of SAW devices (if designed correctly and carefully) is it can replace the conventional RLC circuit in terms of quality and convenience. It can be further improved to expand it's applications in signal processing.

Conclusion/Future Work

•The frequency response was not ideally what was expected, as this device was problematic when fabricated because of the small IDTs and small spaces. Photoresist or aluminum could have been stuck in between the openings causing the signal to become distorted.

•As for future work, more pairs of IDTs can be added and the width of the SAW device can be altered to view behavior. The period can also be varied.

•Optical waveguides (Fig. 9) can now be implemented on this wafer because AlN is a great substrate for optoelectronics.

Fig. 9