CONTROL OF SURFACE ACOUSTIC WAVES WITH DISTRIBUTED VARACTORS

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Abstract

A distributed Schottky barrier varactor junction is described, capable of varying the electrical boundary conditions seen by a surface wave propagating on a piezoelectric medium. Control of the acoustic wave is evidenced by almost 180° of phase shift in 1.75 mm of interaction length at 54 MHz.

Introduction

It is well known that bringing a conducting plane in close proximity to the surface of a piezoelectric medium changes the velocity of sound on that surface.[1] This effect has been used to construct an acoustic phase shifter by suspending a gold film on PZT over a lithium niobate substrate.[2] A conducting plane may also be brought close to the surface of a substrate from within the piezoelectric medium by adjusting the bias of a distributed diode.[3] The electrical boundary conditions in this case are somewhat different and may in fact lead to a substantially greater change in velocity than that due to simply bringing a conducting plane to the surface of the substrate.

Phase Shifter Experiment

A Schottky barrier distributed varactor diode was fabricated for the purpose of observing this effect. The device is shown in Figure 1 and consists of a c-axis cadmium sulfide (CdS) crystal with a thin film gold-CdS Schottky barrier distributed varactor junction. The 5 ohm-cm material was oxygen baked to improve the resistivity under the transducer regions. Aluminum was used for the ohmic contacts, however, we were unable to avoid some rectification at the Aℓ-CdS interfaces. The device operates at 54 MHz, resulting in an interaction region of some 55 acoustic wavelengths in the 1.75 mm long varactor junction.

The performance of the device in terms of phase shift is seen in Figure 2. The relatively high bias voltage required to initiate phase shift is attributed to the voltage necessary to break down the rectifying junction at the Aℓ-CdS interface at the bottom of the structure. A simple calculation indicates that the maximum change in velocity measured implies that $\Delta v/v = 0.0082$ where v is the surface wave velocity. This is substantially greater than the change between a metallized and an unmetallized surface calculated by Tseng of $\Delta v/v = 0.00058$.[4] However, it is less than the value calculated by Schmidt and Voltmer ($\Delta v/v = 0.015$) for the change in velocity between a piezoelectric and a purely elastic wave on a c -plane CdS half space.[5] In Figures 3(a) and 3(b), the input transducer was impulsed in order to achieve synchronous detection of the carrier wave. The triangular pulse shape is a result of the convolution effect of the input and output transducers. It should be particularly noted that there is less than one-fourth dB of added attenuation at maximum phase shift.

Conclusions

As surface acoustic wave circuitry developes in complexity, the need for control devices becomes increasingly evident. The phase shifter reported above possess all the advantages of conventional Schottky barrier devices, including fast switching times, fabrication simplicity and controllability, ruggedness, and economy. Although the device must be constructed on a piezoelectric semiconductor material, advances in the growth of thin film piezoelectric semiconductors may diminish this limitation. In addition to phase shift, many acoustic signal processing functions are envisioned. These include tunable filters, beam scanning (with a prism shaped varactor region), temperature compensation and electronically variable discriminators.

References

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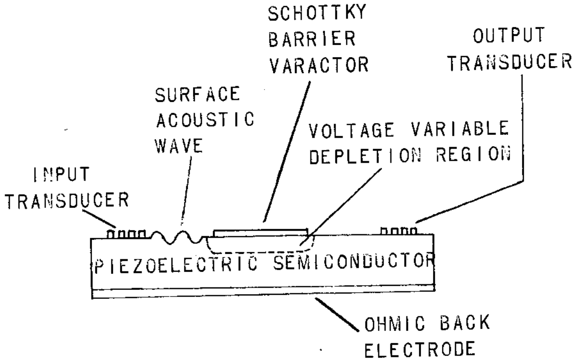
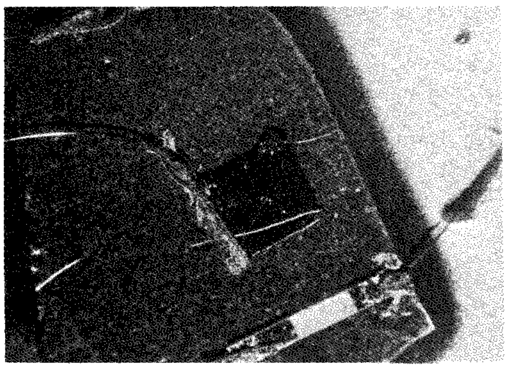


(a)



(b)

FIG.1 Distributed Schottky barrier varactor acoustic phase shifter. (a) Cross sectional view of distributed varactor delay line. (b) Photograph of top view of phase shifter. Active area is a 1.75 mm square Au-CdS varactor(dark region in center.) The bright rectangle at the bottom is one of the interdigital transducers. Crystal is c-plane CdS.

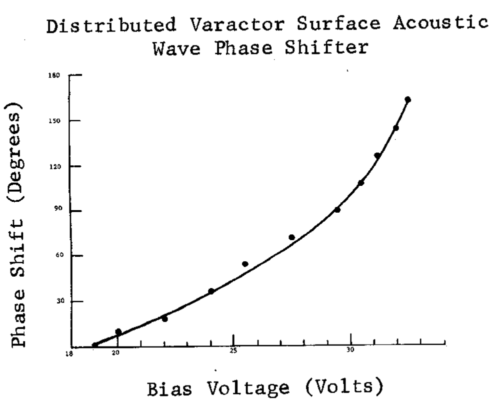
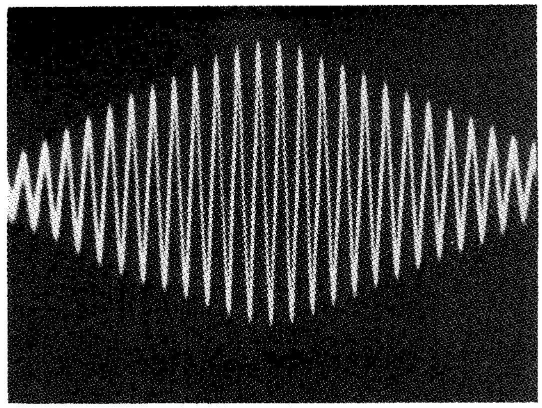
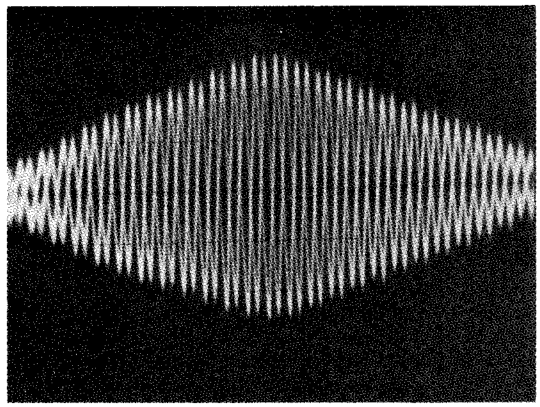


FIG.2 Tuning curve of phase shifter showing variation of phase vs. applied bias.



(a)



(b)

FIG.3 Performance of distributed varactor acoustic phase shifter. (a) Output pulse without bias. Ordinate is relative power, abscissa is time showing 54 MHz carrier signal. (b) Double exposure of output pulse of (b) and the same pulse with maximum varactor bias. Phase shift is near 180°.