DEVELOPMENT OF AN L-BAND PULSE COMPRESSOR USING SURFACE WAVES

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Abstract

Projection printing can be used for definition of interdigital electrode patterns with the third harmonic at 1.3 GHz. Tradeoffs in finger geometry, bulk mode suppression, and control of impedance are considered and experimental results are presented.

Introduction

Surface wave devices have been built and tested at frequencies above 1 GHz for several years. Most of these devices have been difficult to build reproducibly and have had large insertion losses. The most successful devices have been simple tapped delay lines.

A practical pulse compressor must be reasonably easy to build reproducibly in reasonable quantities. The most effective technique currently available for defining metallization patterns with small geometries over the large areas required is a high resolution projection printer. This paper will discuss the design tradeoffs required in the use of projection printing for rapid and effective fabrication of a UHF pulse compressor. The experimental results obtained on lower frequency scaled devices will be analyzed to evaluate these tradeoffs.

Resolution Considerations

The resolution of a lithographic system is dependent on the field of view over which the resolution must be obtained. A total field of 0.15-0.25 inches is required if single exposures are to be used to define devices with dispersion times greater than 0.5 μsec plus the additional delay required between transducers to suppress crosstalk. The best resolution currently available over such a field is one micrometer. Therefore, the device has been designed to operate at the third harmonic of the interdigital pattern on the high velocity cut of lithium niobate (+41.5 degree z-cut, x-propagating).[1] As fringe benefits, the coupling coefficient of this cut is slightly higher than conventional yz lithium niobate and beam steering is less of a problem.

Finger Geometry

Three finger geometries are effective for generating third harmonic signals: wide fingers, narrow fingers,[2] and split fingers.[3,5] All three geometries have been evaluated using devices scaled to 1/10 the design frequency. The results to date favor the use of wide fingers for generating signals at the third harmonic of the finger geometry. Split fingers should cancel electrode reflections exactly at the third harmonic of the finger geometry. However, in wide bandwidth FM devices, the third harmonic of most fingers is not at the frequency of the acoustic wave passing under them resulting in considerable distortion and attenuation. For the particular down-chirp device discussed here, the low frequency signal must pass under electrodes whose second harmonic corresponds to the frequency of the signal. The additional fingers generating coherent reflections result in enhanced reflection instead of suppression. Narrow fingers tend to pass too much scattered light in the projection printer, making it difficult to obtain a good pattern at 1.5 GHz. The additional finger resistance is also undesirable.

Bulk Mode Suppression

Operation at the third harmonic makes some form of bulk mode rejection mandatory. Two promising techniques have been used to suppress bulk modes by up to 20 db across the band. One technique makes use of a thin film prism between the input and output transducers to bend the surface wave without disturbing the bulk mode. The second transducer is canted at a small angle to the first so that it will be in the null of the bulk mode diffraction pattern but will receive the surface wave. The bending of the surface wave results from slowing of the wave due to mass loading, plus shorting of the electric fields if the film is conducting.

The second technique makes use of phase cancellation between two separate sound paths, similar to the technique discussed by LaRosa and Vasile.[4] Bulk mode suppression is obtained by having the finger patterns out of phase in the two sound beams. Acoustic damping material placed in one path removes the surface wave energy which would otherwise cancel energy in the other path. Simplified fabrication results compared to using surface films of controlled thickness, but at the expense of 3 db of insertion loss.

FIG. 1 shows the results of using a thin film prism of conductor on a device at 1/10 frequency. The surface wave is attenuated everywhere by 30 db to show the magnitude of the bulk modes. Curve (a) is a device without a wedge and curve (b) is a tilted device with a wedge, showing 20 db of suppression across the band (105-155 MHz). The response at 40 MHz is due to incomplete damping of the fundamental, not bulk modes.

Device Impedance

Control of device impedance is important in minimizing matching network complexity and insertion loss. For many surface wave devices, the impedance can be varied by changing the device interaction width or by changing the number of fingers in the device. In a pulse compressor, the impulse response is predetermined, preventing large changes in the number of fingers, and the minimum width is normally constrained by beam spreading from the narrow weighted ends. In this device, the resultant impedance was too low. To raise the impedance, the geometry was divided into four horizontal strips which were connected in electrical series, as shown in FIG. 2. The resultant impedance of 30 ohms series resistance and 150 ohms reactance was 16 times larger than the conventional design with the same effective aperture. Parasitic series resistance and capacitance to ground no longer contribute significantly to the insertion loss. It is necessary that the shorting bars follow the shape of the weighting function to prevent diffraction effects from destroying the wavefront at the weighted ends.

Fabrication

FIG. 3 shows the electrodes of a wide finger device fabricated for operation from 1.05-1.55 GHz. FIG. 4 shows the same device at higher magnification. Approximately 20 devices were made on one piece of 41.5 degree rotated cut lithium niobate, 0.025 inch thick, using 10X reduction in a high resolution Mann projection printer. A scanning electron microscope picture of the fingers at the high frequency end (FIG. 5) shows the good line definition obtained. Center-to-center spacing is 4.0 micrometers.

Conclusions

Measurements in the range from 30 to 150 MHz on devices scaled to 1/10 frequency have made possible the rapid development of a design for a UHF pulse compressor capable of being fabricated in quantity using conventional photolithographic techniques on a readily available substrate, lithium niobate. The design is based on operation at the third harmonic of the finger pattern, using bulk mode suppression techniques and varying the finger width to enhance the third harmonic. Series connection results in increased impedance and reduces the effects of parasitic resistance and capacitance on insertion loss. Devices fabricated with a projection printer show the good definition required for UHF operation.

References

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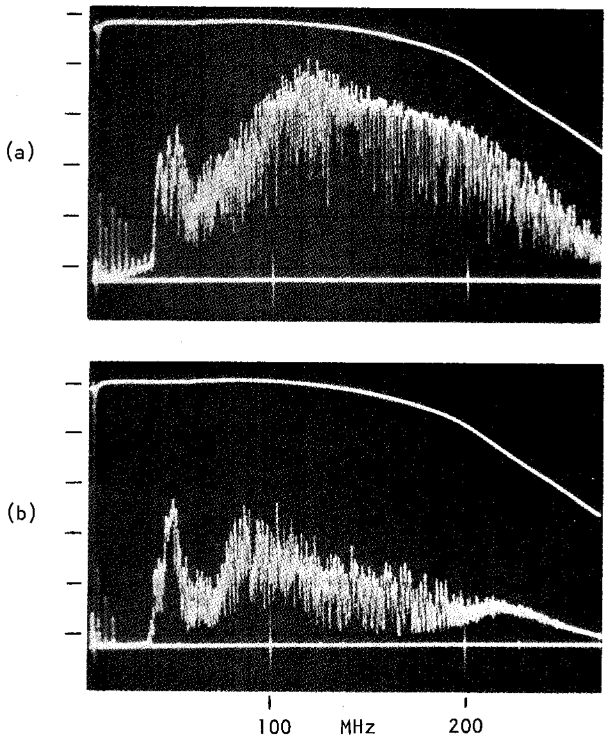

FIG. 1 Bulk Mode Suppression. Reference line at -30 db, 10 db/div.
(a) No suppression
(b) With suppression

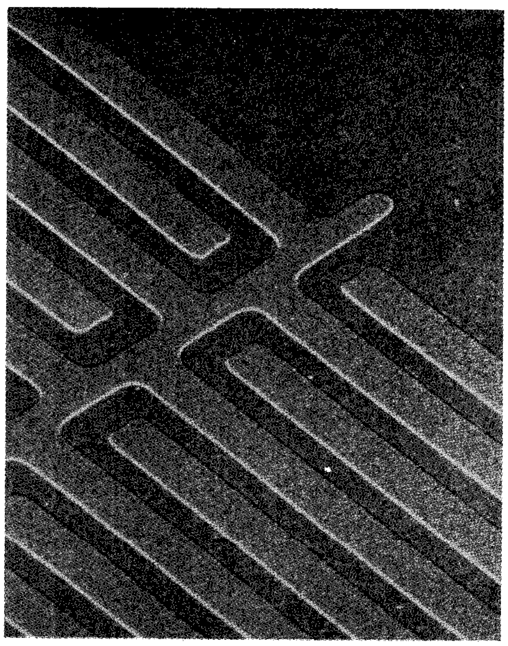

FIG. 5 SEM Photograph of High Frequency End of Transducer.

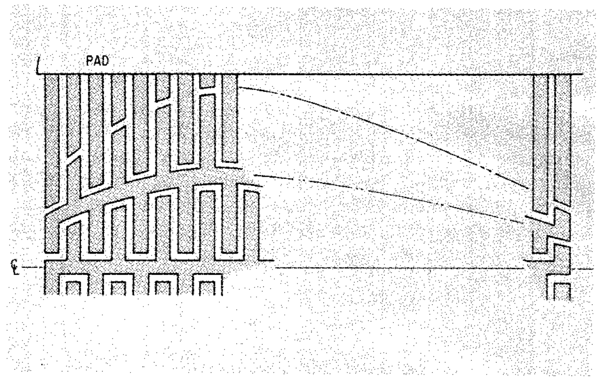

FIG. 2 Schematic of Finger Geometry for Four Segment Series Connection of Overlap Weighted Transducer; Wide Fingers and Dummy Electrodes.

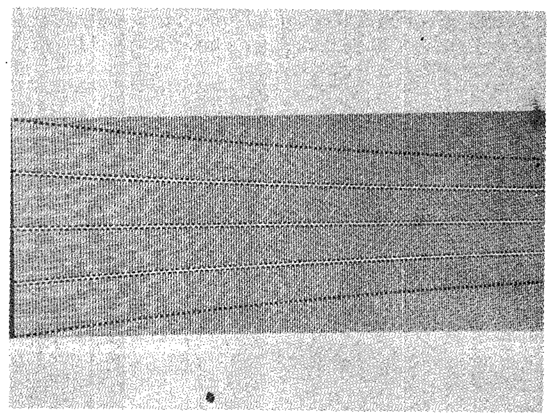

FIG. 3 Photomicrograph of 0.25 microsecond transducer.

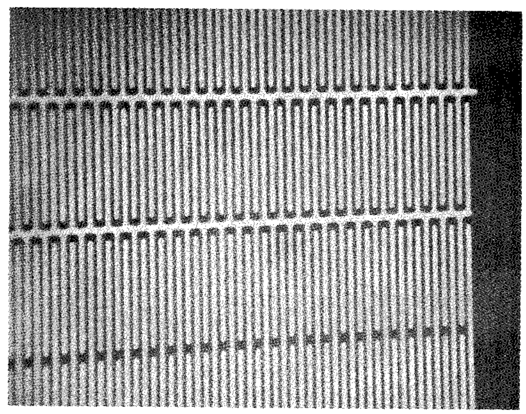

FIG. 4 Photomicrograph of High Frequency End of Transducer, 4 Micrometers Center-to-Center Electrode Spacing.