1-1

CONTROLLABLE NONLINEAR INTERACTIONS BETWEEN ELASTIC SURFACE WAVES AND CARRIERS IN Si-$LiNbO_3$ MIS STRUCTURE

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Recently, considerable attension has centered on the nonlinear interactions between elastic surface waves on the piezoelectric and carriers in the adjacent semiconductor in order to realize compact, active and versatile signal processing devices. The experiments hitherto reported dealt with the generation of second harmonics and convolution signals of surface waves in Si-$LiNbO_3$ [1] and Si-PZT [2] systems, and convolution generation in Si-PZT MIS structure.[3]

Here we report a more detailed and systematic investigation on the surface wave-carrier interactions by means of the acoustoelectric effect, convolution generation and surface-wave amplification in a metal-$LiNbO_3$-SiO_2-Si MIS structure. Use of $LiNbO_3$ permits the operation at higher frequencies and coating Si surface with SiO_2 reduces spurious surface instabilities.

The arrangement used in our experiment is shown in FIG. 1 . FIG. 2 shows the acoustoelectric field E_{ae} (upper traces) detected between two ohmic contacts (c and c′ in FIG. 1). E_{ae} can be varied and even inverted by applying the gate voltage V_G (FIG. 2 and FIG. 3). It should be noted that E_{ae} sensitively reflects the inversion of Si surfaces.

When two surface wave signals are emitted simultaneously from both transducers, the convolution output is observed between c and c′. As shown in FIG. 4, the convolution signal is controlled by V_G.

FIG. 5 shows the amplification of the surface wave by applying a drift field E_d between c and c′. These characteristics are also influenced by V_G.

These nonlinear effects can be interpreted in terms of a second-order product between the ac electric field accompanying the surface wave and the resultant density fluctuation of carriers.

References

1) C.W.Lee and R.L.Gunshor, Appl. Phys. Letters 20 (1972) 288.

2) J.Wolter, Phys. Letters 38 A (1972) 479.

3) M.Yamanishi and T.Kawamura, private communication.

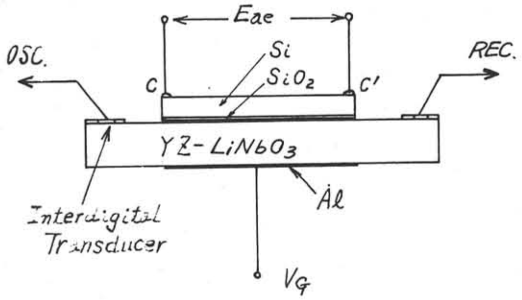


FIG. 1

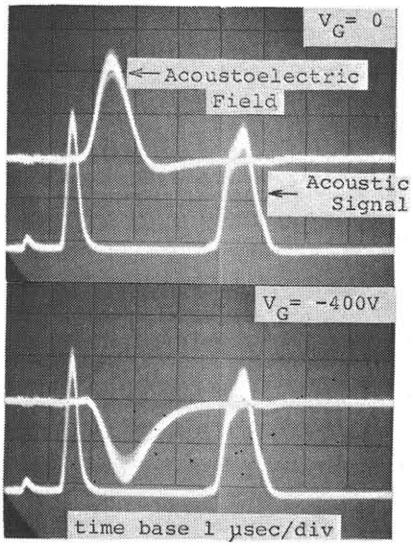
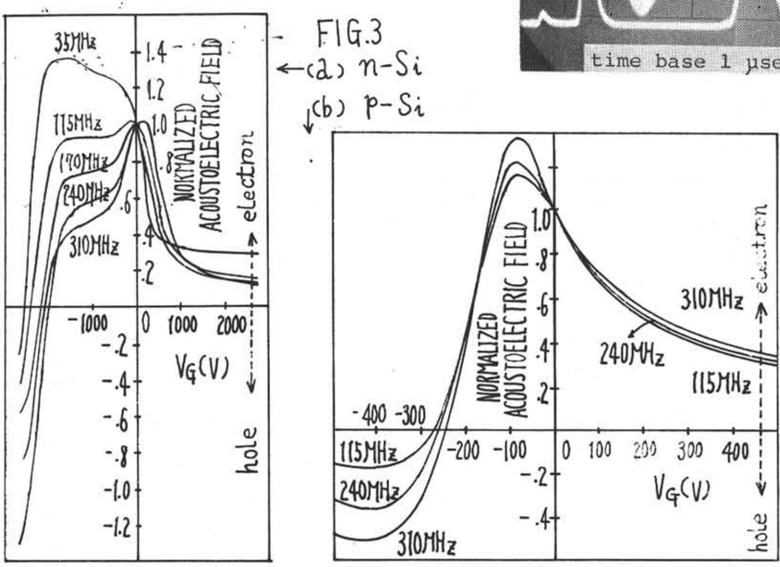


FIG.2
p-Si
310MHz

FIG.3
(a) n-Si
(b) p-Si



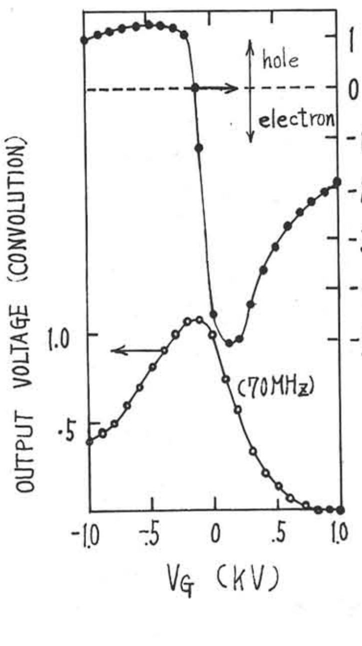


FIG.4 (p-Si)

FIG.5 (n-Si)