CONTROLLABLE NONLINEAR INTERACTIONS BETWEEN ELASTIC SURFACE WAVES AND CARRIERS IN SI-LiNbO₃ MIS STRUCTURE

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Recently, considerable attention 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-LiNbO₃¹ and Si-PZT² 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-LiNbO₃-SiO₂-Si MIS structure. Use of LiNbO₃ permits the operation at higher frequencies and coating Si surface with SiO₂ 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
3) M.Yamanishi and T.Kawamura, private communication.