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Surface Acoustic Wave Memory Using Semiconductor Laser

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Several authors have reported experiments on the storage of surface acoustic wave signals with a coupled semiconductor-piezoelectric convolver.[1-4] In these experiments, the storage of the surface wave signals has been achieved by applying a burst of an electric pulse (rf or dc) to the semiconductor electrode when the surface wave propagates just under the semiconductor surface. We describe here a new method for storing surface wave signals in the semiconductor surface by using a short light pulse from a GaAs laser diode.

Experiments are performed by employing an ordinary silicon-lithium niobate convolver, in which surface waves propagating on the piezoelectric can efficiently couple with carriers in the surface of the semiconductor. When the semiconductor surface is depleted, illumination by light to the surface generates excess charges in the depletion layer, and part of these charges are sent into trapping centers at the semiconductor surface under the influence of electric fields due to the surface waves. If the duration of the light pulse is much shorter than the time period of the surface wave, phase and amplitude of the surface wave can be stored in the surface trapping centers as a charge grating whose spacing is the same as the wave length of the surface wave. As the semiconductor surface is deeply depleted, the decay time constant of charges trapped in the surface state is expected to be of the order of 10 msec.[5] The stored signals can be read-out at the semiconductor electrode as a correlation signal between the stored signal and the reading surface wave which is sent to the delay line after the write-in process.

Experiments were carried out using n-Si whose resistivity is about 100 Ω-cm, placed on the YZ-$LiNbO_3$ with an airgap of 2000 Å as shown in Fig. 1. For write-in, 45 MHz surface wave (power; +15 dBm) was sent to the delay line and a shot of light pulse with the duration of 500

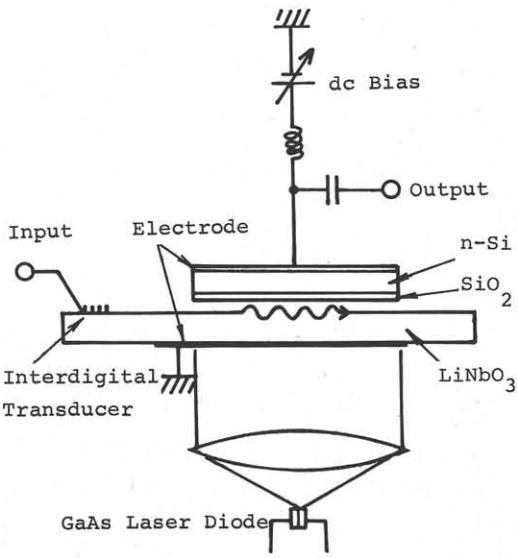

Fig. 1 Experimental configuration

psec from a GaAs diode laser was applied to the semiconductor surface through the semi-transparent electrode on the back surface of the $LiNbO_3$. The peak power of the laser output was about 1 watt. After this process, another surface wave with the same frequency as used in the write-in process was sent and the correlation signal with the stored signal was obtained at the semiconductor electrode. In both processes, a dc bias voltage of about +1.2 kV was applied to the semiconductor in order to deplete the semiconductor surface.[2] Figures 2(a) and 2(b) show the correlation signals read-out after 0.1 msec and 1.0 msec, respectively. The fluctuation of the output signal levels which is seen in the figure is attributed to the fluctuation of the laser output. As shown in Fig. 3, the decay time of stored signals was of the order of milliseconds, which indicates that the surface state at the Si-SiO_2 interface acts as the storage center[2] in our case.

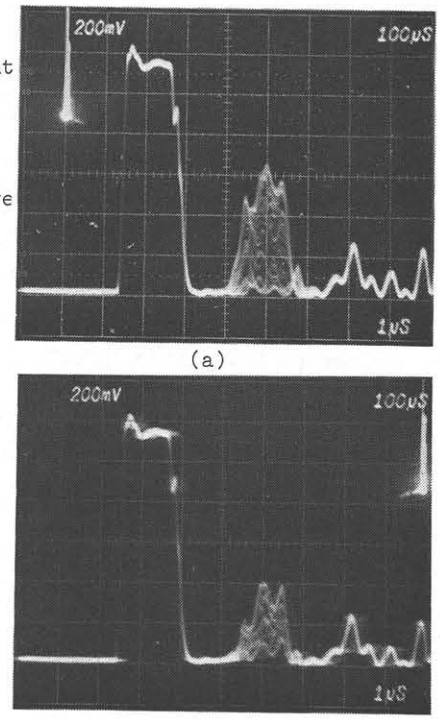

Fig. 2 Correlation signals read out after 0.1 msec (a) and 1 msec (b).

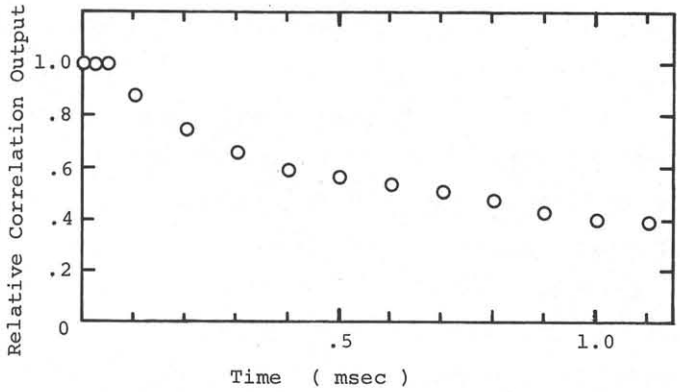

Fig. 3 Stored signal amplitude vs. time.

In conclusion, we have demonstrated a new surface wave memory-correlator using a laser diode. This method has ability to store large band width signals, which would allow us to realize memory devices for various signals such as FM chirps. Our future intention is to work with devices with longer storage time.

1) A. Bers and J.H. Cafarella: Appl.Phys.Lett. 25(1974)135.

2) H. Hayakawa and G.S. Kino: ibid. 25(1974)178.

3) C. Maerfeld, Ph. Defranoud, and P. Tournois: ibid. 27(1975)577.

4) K. Ingebrigsten and E. Stern: 1975 Ultrasonic Symposium Proc.,IEEE Cat.#CHO 994-4SU, p.212.

5) E.H. Nicollian and A. Goetzberger: Bell Syst. Tech. J. 46(1967)1055.