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Surface-Wave-Acoustoelectric Image Scanner

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Elastic surface waves can be applicable to an image scanning device because they have a constant propagation speed and a function of spatial resolution. Recently, optical scanning devices using surface waves propagating on the piezoelectric have been proposed by several authors.[1)-4)]

Kaufman and Foltz[1)], and Asakawa and Uchida[3)] have reported scanning devices with an optical sensor array which is connected to tapped electrodes constructed on the piezoelectric surface. Without using tapped electrodes, Moll et al.[4)] have achieved image scanning by using a nonlinear interaction of two surface waves through a semiconductor film whose conductivity is modulated by an optical pattern.

In this paper, we report a new and simple image scanning method using the longitudinal acoustoelectric effect in the coupled semiconductor-piezoelectric system. In this configuration the acoustoelectric field is induced in the semiconductor by interactions between surface waves propagating on the piezoelectric and carriers in the adjacent semiconductor surface. If an air-gap between the piezoelectric and the semiconductor is well controlled to be uniform in space, a rectangular dc pulse of acoustoelectric voltage can be obtained between two ends of the semiconductor when a short surface wave pulse moves along the piezoelectric. When an optical pattern is applied to the semiconductor surface, its conductivity is changed by optically generated carriers, resulting in the modulation in the acoustoelectric voltage. Therefore, we obtain a perturbed waveform of acoustoelectric voltage which corresponds to the spatial variation of light intensity, thus effecting one dimensional scanning.

The experimental arrangement is shown in Fig.1. Short pulses of surface waves (frequency: 87 MHz, time duration: 400 nsec, beam width: 0.5 mm) are generated on the Y-Z $LiNbO_3$ plate by using an interdigital transducer with five pairs of electrodes whose periodicity is 40 μm. We used p-type silicon coated with thermally grown SiO_2 layer as a semiconductor. A sample with two ohmic contacts is placed onto the $LiNbO_3$ surface through SiO_2 spacers so as to hold an air-gap of about 600 Å.

Figure 2(a) shows an example of acoustoelectric output signal without illumination in a 20Ωcm p-Si sample coated with a 2700 Å SiO_2 layer. When a 6328 Å He-Ne laser spot with a diameter of 0.5 mm (the power ≃ 1.2 mW) is applied to the semiconductor surface, the output signal changes as shown in Fig.2(b). In a p-type silicon with SiO_2 layer, surface waves can be dominantly coupled with electrons in weak inversion layer[5] when the illumination is absent. Under the illumination, the surface potential is decreased by the generation of electron-hole pairs[6] and holes begin to contribute to the acoustoelectric voltage,resulting in the strong modulation in output signal. In fact, we observed that the modulation in the acoustoelectric voltage by light in samples coated with SiO_2 is much stronger than that in samples without SiO_2 layer.

A photograph shown in Fig.3 is an oscilloscope display of an image resolved with the present method. The photograph is obtained by moving the device perpendicular to 0.5×15 mm line at the focal plane.

Resolution limit obtained at the present stage was 2 lines/mm. The higher frequency and the shorter pulse width of surface waves would increase this resolution. This method will give a possibility of fabricating an image scanning device which is entirely solid state and has a simple structure and high scanning speed.

References: 1) I. Kaufman and J.W. Foltz:Proc.IEEE 57 (1969) 2081. 2)V.O. Blackledge,M.D. Sirkis, and I. Kaufman:IEEE SC-5 (1970) 244. 3)K. Asakawa and I. Uchida: Proc. 4th CSSD,Japan(1972). 4)N.J. Moll,O.W. Otto, and C.F. Quate:M.L.Report No. 2095 (1972),Stanford Univ. 5)S.Takada,K.Hoh,H.Hayakawa,and N.Mikoshiba:Proc. 4th CSSD,Japan(1972). 6)S.M.Sze:Physics of Semiconductor Devices (1969) Chapter 9.

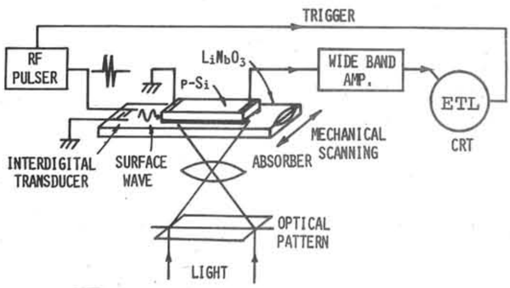
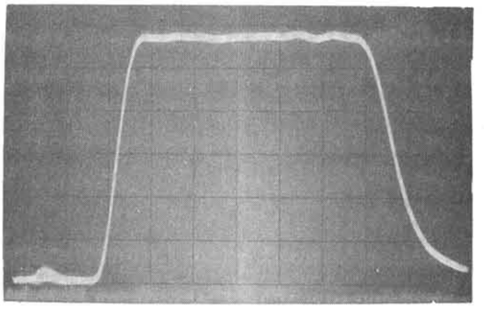


Fig.1



Horizontal:0.7 µsec/div.
Vertical:4 mV/div.

Fig.2(a)

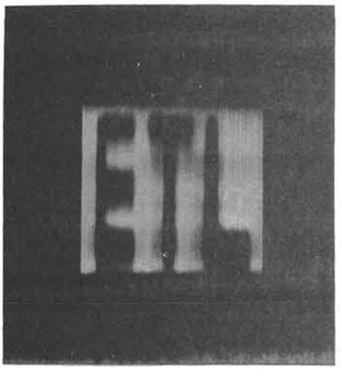


Fig.3

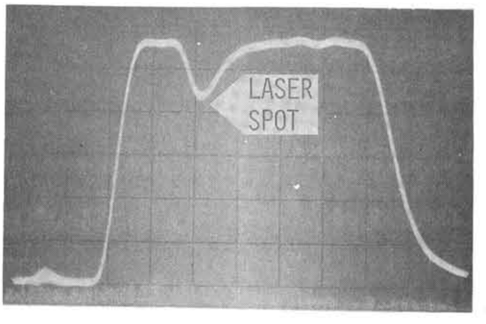


Fig.2(b)