Phonon echo using acoustic surface waves

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We observed phonon echo with acoustic surface waves in lithium niobate. We investigated the case of a nondegenerate excited echo. The advantages of phonon echo with surface waves over echo with volume waves are discussed.

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The phenomenon of electroacoustic (phonon) echo with volume waves in piezoelectric crystals, discovered in[1,2], has been actively investigated of late. One of the stages in the formation of the phonon echo is generation of an inverted acoustic wave by parametric interaction of the direct wave with the electric field. It is known that if acoustic surface waves are used the parametric interaction is more effective than with volume waves.[3] It can be assumed that the phonon-echo signals will also be more intense if acoustic surface waves are used. Up to now, however, the existence of phonon echo for acoustic surface waves has not been proved experimentally.

We have investigated phonon echo with acoustic surface waves in lithium niobate. The Rayleigh surface waves were excited with an interdigital converter 1 with aperture 1 mm, deposited on a sound-transmission line of YZ-cut $LiNbO_3$ (Fig. 1). A packet of forward acoustic waves was excited at a frequency $f_1 = 43$

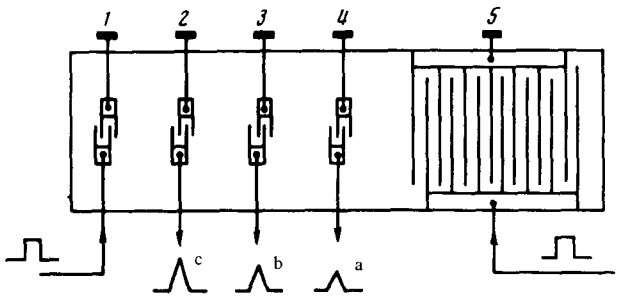

FIG. 1. Experimental setup for the observation of phonon echo using acoustic surface waves: 1—input transducer, 2,3 and 4—output transducers, 5—parametric electrode.

MHz by a pulse of duration 1.5 μsec and amplitude 0.7 V. After propagating to the sound line, the waves in the packet became dephased in velocity and in direction. After a time $\tau = 7.8$ μsec, when all the initial waves were under the parametric electrode 5, an RF pulse of 2 μ sec duration, 11.5 V amplitude and frequency $f_3 = 72$ MHz was applied to this electrode. By virtue of the acoustic synchronism in the parametric interaction, a wave with wave vector opposite

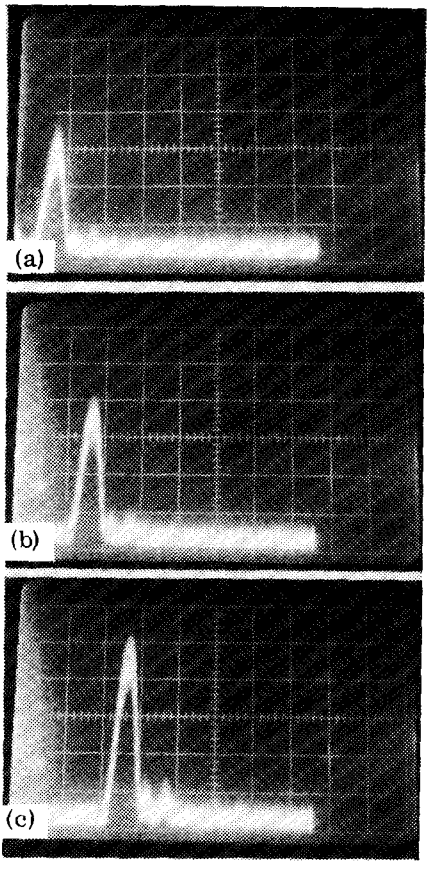

FIG. 2. Oscillograms of output signals of transducer 4(a), 3(b), and 2(c). Horizontal scale—2 μsec/div, vertical scale—0.2 V/div.

to the wave vector of the forward wave was excited, at a frequency $f_2=f_3-f_1$ = 30 MHz. This wave was received in succession by three output transducers 2, 3, 4 tuned to 30 MHz and separated from one another by distances corresponding to a 2 μsec wave-propagation time. The output signal amplitude increased monotonically on going from transducer 4 to transducer 2 (Fig. 2), thus proving the presence of phasing of the oscillations in the backward wave packet, i.e., of phonon echo.

It should be noted that the earlier investigations were devoted as a rule to degenerate cases of parametric interaction: an acoustic wave of frequency f interacted with an electric field of frequency $2f$. In these experiments we used the case of nondegenerate parametric interaction, which offers a number of advantages in comparison with the case of degenerate interaction. First, at equal electric voltages on the parametric electrode, it becomes possible, as a result of the configuration of the transducer, to obtain a larger electric field intensity; second, the phonon-echo signal can be easily separated from the input signals in the frequency region.

Among the features of the use of acoustic surface waves to obtain phonon-echo signals is the lower power level of the input signal than in the case of phonon echo with volume waves,[1] this being apparently due to the high degree of localization of the energy in the surface waves. An even greater gain in power can be expected by using acoustic edge waves,[4] in which the localization of the energy is even higher.

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