Guided elastic waves in one-dimensional phononic crystal

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Surface acoustic wave transduction by the use of interdigital transducers (IDT's) is a well-known and widespread technique. An IDT forms a one-dimensional array of metal electrodes on a surface, devised in view of the electrical transduction in piezoelectric materials. However, usual IDT's make use of electrodes with limited heights, so that surface mode properties do not differ appreciably from those of a free or a fully metallised surface. We proposed previously [V. Laude *et al.*, J. Appl. Phys. 90, 2492 (2001)] a theoretical analysis of the transduction of SAW under a metallic array of electrodes with a large aspect ratio on a piezoelectric substrate, whereby allowing the electrode height to become larger than one wavelength.

We here report on the experimental observation of the multimode character of SAW propagation under periodic arrays of electrodes. We also obtain experimentally the explicit dependence of the SAW velocities as a function of the electrode height. In that purpose, we fabricated interdigital transducers on the Y+128 cut of lithium niobate using electroplating of nickel. The slightly pyramidal electrodes are up to five times higher than wide. The experimental variation of the resonances frequencies of the various surface modes was obtained experimentally. Up to a 10-fold slowing of surface waves is observed, with the phase velocity dropping from 4000 m/s down to 450 m/s. The comparison a theory based on a coupled finite-element boundary element- method is excellent. In the system such as investigated here, the conversion of surface acoustic waves into bulk waves is strongly inhibited by the slowing of surface modes and the results could well be useful in the design of filters for surface acoustic waves and more generally of periodic transducers on piezoelectric materials. Another peculiar property of high aspect ratio IDT's is the very slow group velocity associated with the propagation of the energy of the surface acoustic waves. Special emphasis will be paid to the estimation of the group velocity in delay line devices. An optical characterization by heterodyne interferometer will be also presented.