NONLINEAR SURFACE ACOUSTIC WAVES
IN CUBIC CRYSTALS

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Model equations developed by Hamilton, Il'inskii, and Zabolotskaya [*J. Acoust. Soc. Am.* **105**, 639–651 (1999)] are used to perform theoretical and numerical studies of nonlinear surface acoustic waves in a variety of nonpiezoelectric cubic crystals. The basic theory underlying the model equations is outlined, quasilinear solutions of the equations are derived, and expressions are developed for the shock formation distance and nonlinearity coefficient. A time-domain equation corresponding to the frequency-domain model equations is derived and shown to reduce to a time-domain equation introduced previously for Rayleigh waves [E. A. Zabolotskaya, *J. Acoust. Soc. Am.* **91**, 2569–2575 (1992)]. Numerical calculations are performed to predict the evolution of initially monofrequency surface waves in the (001), (110), and (111) planes of the crystals RbCl, KCl, NaCl, CaF_2, SrF_2, BaF_2, C (diamond), Si, Ge, Al, Ni, Cu in the $m\bar{3}m$ point group, and the crystals Cs-alum, NH_4-alum, and K-alum in the $m\bar{3}$ point group. The calculations are based on measured second- and third-order elastic constants taken from the literature. Nonlinearity matrix elements which describe the coupling strength of harmonic interactions are shown to provide a powerful tool for characterizing waveform distortion. Simulations in the (001) and (110) planes show that in certain directions the velocity waveform distortion may change in sign, generation of one or more harmonics may be suppressed and shock formation postponed, or energy may be transferred rapidly to the highest harmonics and shock formation enhanced. Simulations in the (111) plane show that the nonlinearity matrix elements are generally complex-valued, which may lead to asymmetric distortion and the appearance of low frequency oscillations near the peaks and shocks in the velocity waveforms. A simple transformation based on the phase of the nonlinearity matrix is shown to provide a reasonable approximation of asymmetric waveform distortion in many cases. Finally, numerical simulations are corroborated by measured pulse data from an external collaboration with P. Hess, A. Lomonosov, and V. G. Mikhalevich. Pulsed waveforms in the (001) and (111) planes of crystalline silicon are quantitatively reproduced, and two distinct regions of nonlinear distortion are confirmed to exist in the (001) plane.