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New Shear Horizontal (SH) Surface Acoustic Waves Propagating at the Interface between Two Elastic Half-Spaces

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Background, Motivation and Objective

Your text explaining what has been done previously and why this work is of importance.

It can be shown that the shear horizontal (SH) surface waves cannot propagate at the interface of two elastic half-spaces, regardless of their symmetry and/or orientation (Achenbach, 1973). In this presentation we will challenge this assertion, showing that shear horizontal (SH) elastic surface waves can propagate along at the interface between two elastic-half-spaces, providing that one of them is an elastic metamaterial with special properties, i.e., with a negative shear elastic compliance s_{44}. The proposed new (SH) surface waves have only one transverse component of the mechanical displacement, which attains a maximum at the guiding interface and decays exponentially in the direction perpendicular to the interface.
It is worth noting that this new acoustic surface wave is a direct analog of Surface Plasmon Polariton (SPP) electromagnetic waves propagating along the metal-dielectric interface (Zhang et al., 2012; Maier, 2007). The transverse mechanical displacement u_3 of the new proposed acoustic surface wave corresponds to the transverse magnetic (TM) field H_3 of the surface electromagnetic wave of the SPP type. The new acoustic surface waves inherit a large number properties of the electromagnetic surface waves of the SPP type. Among others, new acoustic surface waves are characterized by a strong subwavelength concentration of the wave field in the proximity of the interface.

Statement of Contribution/Methods

Description of equipment, methods used.

Employing the equations of motion, constitutive equations and the appropriate boundary conditions at the guiding interface, we have developed analytical expressions for the dispersion relation, phase velocity v_p and group velocity v_{gr} of a new shear horizontal (SH) elastic wave, propagating along the guiding interface.

Results/Discussion

Presentation of the results obtained and discussion of the results.

We have shown that shear horizontal (SH) acoustic surface waves can propagate along the interface between two rigidly bonded elastic half-spaces, if one of them is an elastic metamaterial with a negative elastic compliance.
The phase v_p and group v_{gr} velocities of the new acoustic wave slow down and tend to zero as the wave frequency f approaches the surface resonant frequency f_{sp}. This is rather a very unusual feature among acoustic waves. Consequently, the proposed new surface acoustic waves can exhibit very high sensitivity to mass loading of the guiding interface. The dispersion relation, phase velocity and group velocity, as a function of frequency, were calculated and plotted for an exemplary waveguide structure based on the PMMA and Quartz half-spaces. The surface resonant frequency $f_{sp} = 143.67\ kHz$.
The penetration depth of the proposed new (SH) acoustic surface wave can be deeply subwavelength λ (e.g., of the order of $\lambda/10$). Due to such a strong concentration of the acoustic field in the vicinity of the interface, the proposed new surface acoustic waves can be applied in highly sensitive sensors of physical quantities (e.g., viscosity), biosensors, chemosensors, near field acoustic microscopy (with subwavelength resolution), as well as in miniaturized micro and nano-scale modern acoustic devices.

1. Achenbach J.D. (1973), *Wave Propagation in Elastic Solids*, North-Holland, Amsterdam.
2. Maier S.A. (2007), *Plasmonics: Fundamentals And Applications*, Springer, Berlin.
3. Zhang J., Zhang L. and Xu W. (2020), *Surface plasmon polaritons: physics and applications*, Journal of Physics D: Applied Physics, **45**, 113001 (19pp).