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Non-Linear Transformation of Bulk Acoustic Waves at Oblique Incidence on Plane Solid Boundary

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Abstract : The transformation of two types of acoustic waves can occur on a flat interface between two solids at oblique incidence of longitudinal and shear bulk acoustic waves (BAW). This paper presents the results of experimental studies of the properties of reflection and propagation of longitudinal wave and generation of second and third longitudinal and shear harmonics of BAW at oblique incidence of longitudinal BAW on a flat rough boundary between two solids. The experimental sample was a rectangular isosceles pyramid made of D16 aluminum alloy with the plane parallel bases cylinder made of D16 aluminum alloy pressed to the base. The piezoelectric lithium niobate transducer with a resonance frequency of 5 MHz was secured to one face of the pyramid to generate a longitudinal wave. Longitudinal waves emitted by this transducer felt at an angle of 45° to the interface between two solids and reflected at the same angle. On the opposite face of the pyramid, and on the flat side of the cylinder was attached longitudinal transducer with resonance frequency of 10 MHz or the shear transducer with resonance frequency of 15 MHz. These transducers also effectively received signal at a frequency of 5 MHz. In the spectrum of the transmitted and reflected BAW was observed shear and longitudinal waves at a frequency of 5 MHz, as well as longitudinal harmonic at a frequency harmonic of 10 MHz and a shear harmonic at frequency of 15 MHz. The effect of reversing changing of external pressure applied to the rough interface between two solids on the value of the first and higher harmonics of the BAW at oblique incidence on the interface of the longitudinal BAW was experimentally investigated. In the spectrum of the reflected signal from the interface, there was a decrease of amplitudes of the first harmonics of the signal, and non-monotonic dependence of the second and third harmonics of shear wave with an increase of the static pressure applied to the interface. In the spectrum of the transmitted signal growth of the first longitudinal and shear harmonic amplitude and non-monotonic dependence - first increase and then decrease in the amplitude of the second and third longitudinal shear harmonic with increasing external static pressure was observed. These dependencies were hysteresis at reversing changing of external pressure. When pressure applied to the border increased, acoustic contact between the surfaces improves. This increases the energy of the transmitted elastic wave and decreases the energy of the reflected wave. The second longitudinal acoustic harmonics generation was associated with the Hertz nonlinearity on the interface of two pressed rough surfaces, the generation of the third harmonic was caused by shear hysteresis nonlinearity due to dry friction on a rough interface. This study was supported by the Russian Science Foundation (project №14-22-00042).

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