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On the influence of ionizing radiation on the acoustic waves in acoustoelectronic devices

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Acoustoelectronic devices are widely used in modern information technologies. Study of influence of ionizing radiation on volumetric and surface acoustic waves in such devices is of interest. In the present paper the methods of account of this influence by including the inhomogeneous members, which describe the sources, into the basic equations are considered.

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Acoustoelectronics is an area of science and technology which studies and uses interaction of high-frequency acoustic waves with electromagnetic fields and free electrons in solids. Investigation of the influence of ionizing radiation (IR) on volumetric (VAW) and surface (SAW) waves in various acoustoelectronic devices (strip filters, lines of a delay, sensor controls, etc.) are carried out in many scientific centers [1, 2]. On the other hand, it seems to be of interest to analyze the possibilities of determination of parameters of charged particles, which penetrate into the area of interrelated acoustic and electromagnetic waves, by registration of their output response to IR

Formulation of problem. The beam of the charged particles falls on an element of acoustoelectronic device with SAW. As a rule, in such devices SAW is generated by some contrary-probe structures – metal lattices on a surface of a piezoelectric material. The period of a lattice at operating mode is equal to the length of a SAW, and frequency of the impressed voltage is equal to SAW frequency.

As is known, interaction of penetrating radiation with a substance results in the generation of sound waves [3, 4]. Theoretical researches [5] prove a possibility of dosimetry of IR by the acoustic methods at rather high intensity and energy of beams [6]. The most extensively studied method of sound generation by penetrating radiation in condensed medium is the thermo-radiative mechanism: thermal energy, which is produced by interaction of charged particles with substance, will be transformed to energy of sound waves. However, as to influence of IR on operating mode of an acoustoelectronic device, a mechanism of the direct influence of charges and currents, produced by IR in the media, on electromagnetic component of wave processes can be the most significant. Estimations of this influence, in view of compactness and high sensitivity of elements of acoustoelectronic devices [7], allow to assume that registration of response to IR (e. g. of variations of calibrating signal) enable to get not only a data of global characteristics of IR, but also essentially more detailed information on IR parameters.

Basic equations. For the account of the influence of charges and currents, generated by IR in media, on the interrelated acoustic and electromagnetic waves it is necessary to include the inhomogeneous members describing sources into the basic equations of acoustoelectronics [8, 9]. First of all, let us take into account the density of "foreign" charges ρ_e^{ext} produced by ionization of substance due to penetrating radiation:

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$$\rho \frac{\partial^2 u}{\partial t^2} = \frac{\partial T_{ij}}{\partial x_i}, \quad T_{ij} = C_{ijkl} S_{kl} - e_{kij} E_k,$$

$$D_i = e_{ikl} S_{kl} + \varepsilon_{ik} E_k, \quad \frac{\partial D_i}{\partial x_i} = 4\pi \rho_e^{ext},$$

where D_i is the vector of an electric induction, T_{ij} is the tensor of pressure, c_{ijkl} is the tensor of elasticity coefficients, e_{ijk}, ε_{ik} are the tensors of piezo- and dielectric constants, ρ is the density of a piezoelectric material, u_i represents a vector of displacement. Using this approach, it is easy to show that, for example, a particle with energy of 1 Mev, as a result of ionization of substance, can induce variations of electric field about 10^{-2}V/cm in an acoustoelectronic element and generate perturbances of calibrating signal essentially exceeding a noise level.

Thus, the use of acoustoelectronic elements for dosimetry and spectrometry of IR seems to be rather perspective.

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