C—5—6 Observation of the Effective Diffraction of Submillimeter Radiation on the Electronic Waves in n-InSb

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A new mechanism of the acoustooptic interaction due to light scattering on the waves of free electrons accompaning the piezoactive acoustic waves in a conductive media was predicted in 1972 [1]. It was shown that the efficiency of this type diffraction increased with a growth of the electromagnetic wave length up to the plasma frequency. Firstly, the electronic type of light diffraction was discovered at a wave length 10.6 μm in Cds [2]. However, the efficiency of the diffraction under these conditions was quite unsufficient because the plasma frequency was too small in comparison with the frequency of light.

This paper reviews the first experimental researches of the efficiency of diffraction of the submillimeter electromagnetic waves on the electronic waves in the piezosemiconductive n-InSb where the large efficiency may be expected [1].

The backward-wave oscillator tuned in the range of the wave lengths from 0,5-1 mm with the output power about 5 m W and with the frequency stability $\frac{\delta\omega}{\omega} \sim 10^{-4}$ was used as an electromagnetic wave emitter. The standard elements of a quasioptic spectrometer [3] provided the formation of the circular profile of the cross-section Q = 8 mm on a surface of the sample of n-InSb placed into a cryostat at the temperature of liquid nitrogen. The diffracted radiation so as reflected from the surface of the crystal was detected by the photoresistive detector fabricated on the base of the other crystal InSb. Just after amplification and radiodetection, the signal was registered on an oscillograph and plotter.

The geometry of the collinear light and sound interaction with the contraverse direction of the wave propagation was used. The free electron wave was formed in the samples of n-InSb under the propagation of a piezoactive, shear, ultrasonic wave on the direction along $\{110\}$. The samples of n-InSb with the equilibrium concentration of free electrons about $2\cdot10^{12} - 10^{13}$ cm^{-3} at 78^{o}K, with the electron mobility $\mu_n \simeq 2\cdot10^{5}$ cm^{2} /V·sec have sizes 10x10x15 mm^{3}. The sound with frequency about 20-30 MHz was generated by the $LiNbO_3$ half-wave length resonant transducers. The maximum sound intensity in samples was about 50 W/cm^{2} with the pulse duration τ = 10 μsec and repetition frequency $f_R \simeq 5$ Hz.

The value of the diffracted signal was measured experimentally as a function of temperature. In this case the sound frequencies corresponding to the Bragg synchronism at various temperature were tuned (from fs = 27,4 MHz at 78^{o}K to fs = 26 MHz at 140°K). This is explained by the dependence of the dielectric constant of crystals at the temperature dependence of concentration of free electrons in samples. The maximum diffraction efficiency was observed at $T = 78^{o}K$ and accounted for 60%. This high diffraction efficiency cannot be explained by a usual photoelastic interaction because the diffraction efficiency must be extremly small ($\eta_{ph} \sim 0{,}001$) at the known value of the acoustooptic merit of quality in this material $M_2 = 10^{-15}$ sec^3 /g [4]. At the same time the diffraction efficiency on the electronic waves η_e according to [1] were in a good agreement with the experimental data obtained.

Thus, all results show that the observed efficient diffraction of submillimeter radiation relates to the acoustooptic interaction on the waves of free electrons in n-InSb. The diffraction efficiency is very high for the elecrtomagnetic waves in a given region, that is in a good agreement with the theory predictions.

R E F E R E N C E S

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