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SURFACE WAVES IN InSb

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In an investigation of the passage of electromagnetic waves through single-crystal n-InSb samples at T = 300°K in a constant magnetic field, we observed a small surface electromagnetic wave with circular polarization and with nearly-linear dispersion. The wave propagated parallel to the magnetic field and was observed at $\omega \ll \omega_{ci} < \nu_i$ simultaneously with the well-known helical waves (helicons) at $\omega \ll \nu_e \ll \omega_{ce}$ (ν_e and ν_i are the characteristic electron and hole collision frequencies and ω_{ce} and ω_{ci} are their respective cyclotron frequencies). The experimental setup is shown in Fig. 1.

The n-InSb plates were placed between two coupling coils producing and sensing electromagnetic HF fields directed along their axes. The HF signal passing through the plates, with frequencies 15 - 1000 MHz, was recorded as a function of the constant magnetic field $H_z < 30$ kOe normal to their planes. When the coupling coils were placed at the center of the sample, an intense helicon size-effect resonance was observed (curve 1 of Fig. 2), the frequency of which satisfied the relation $\omega = k_z^2 H_z c/4\pi n_e \ell$, where $k_z = \pi/d$ is the longitudinal wave number, d the plate thickness, c the speed of light, e the electron charge, and $n_e = 1.35 \times 10^{16}$ cm^{-3} the electron concentration in our samples. Whenever the coupling coils were near the edges of the plates, a surface-wave resonance was produced simultaneously with the helicon resonance in somewhat weaker fields (curve 2 of Fig. 2), and we could observe these resonances, depending on the setting of the system, either together or separately, and either of them could be separated. When the magnetic field made a certain angle with the normal to the plate, a shift of the surface-wave resonance towards stronger magnetic fields was observed; this shift was proportional to the cosine of this angle, in analogy with the situation with helicons. None of the resonances were observed in a transverse magnetic field.

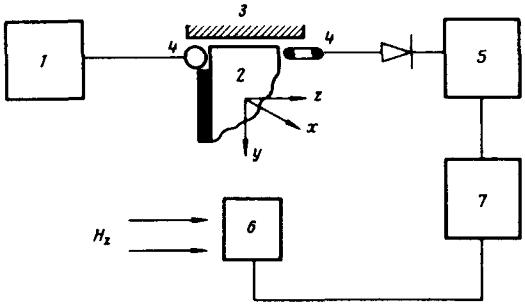

Fig. 1. Experimental setup: 1 - HF generator, 2 - sample, 3 - screens, 4 - coupling coils, 5 - amplifier, 6 - Hall pickup, 7 - x-y recorder.

The observed wave was identified as a surface wave on the basis of measurements of its intensity distribution as a function of the depth (curve 3 of Fig. 2); these measurements were performed by suitably shifting the receiving coupling coil. The wave intensity was maximal at the surface of the side face of the plate and decreased with depth (y axis) like $I = I_0 \exp(-2\tau y)$, where $\tau = 6$ cm^{-1}. This means that the wave is localized in a layer much

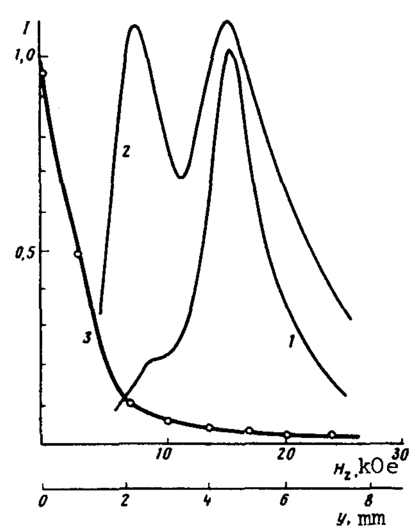

Fig. 2

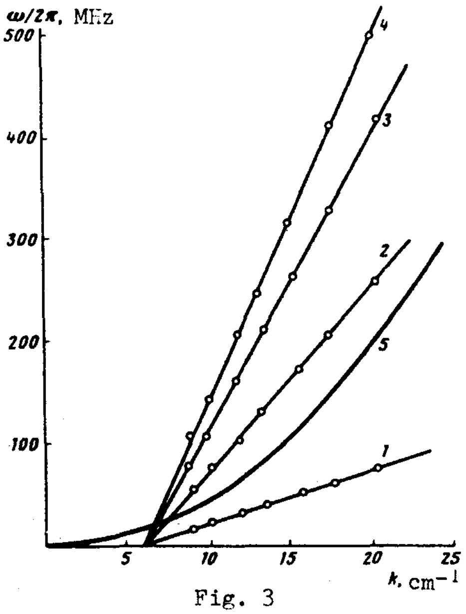

Fig. 3

Fig. 2. Intensity of the HF signal passing through the n-InSb sample vs. the magnetic field when the coupling coils are placed at the center of the sample (1) and at its edge (2), and also variation of the surface-wave intensity with depth (3). Sample dimensions 15 × 15 × 0.9 mm, frequency 700 MHz.

Fig. 3. Dispersion characteristics of surface waves at different values of the magnetic field H_z (1 - 3 kOe, 2 - 5 kOe, 3 - 7 kOe, 4 - 9 kOe) and dispersion characteristic of a volume helicon (5) at H_z = 9 kOe for the same sample.

thicker than the classical skin layer at $H_z = 0$. By varying the orientation of the coupling coils, we found that the wave has a circular polarization; in addition, we observed in it a longitudinal component of the HF magnetic field.

Owing to the strong reflection of the surface wave from the edges of the plate, the face of the latter constitutes, as it were, a Fabry-Perot resonator. By varying the thickness of such a resonator during the course of the experiment (by grinding down the plates) we measured the dependence of the surface-wave resonant frequency on the magnetic field for different thicknesses, and could therefore plot the dispersion curves of the wave for different values of H_z. They are shown in Fig. 3.

The family of the dispersion characteristics of the surface waves has the following properties not possessed by waves of the helicon type. First, it constitutes a bundle of nearly straight lines converging at $\omega = 0$ to the point $k_z \simeq \tau$, apparently owing to the surface character of the wave. At this point, the wave phase velocity $v = \omega/k_z$ tends to zero, so that the existence of homogeneous surface waves at $k_z < \tau$ is apparently impossible. Second, at $k_z > \tau$ v tends to zero at a certain finite magnetic field regardless of the value of k_z; the damping of the wave then increases and its resonance is no longer observed. In strong fields, judging from the Q of the resonance, the damping of the surface wave does not exceed the damping of the volume helicons.

In the wavelength region investigated by us, the surface-wave phase velocity was $10^7 - 10^8$ cm/sec and was approximately double the helicon phase velocity. However, if the dispersion characteristics remain linear outside this range, then they should cross the quadratic dispersion characteristics of the helicons at two points, so that at these points one should expect different singularities to appear.

It is physically clear that the existence and the properties of the surface waves must of necessity follow from the simultaneous solution of Maxwell's equations and the equations of motion for the carriers in the semiconductor under suitable boundary conditions and, apparently, with allowance for the presence of carriers of both sides, inasmuch as at $T = 300°K$ the conductivity of our InSb samples was close to the intrinsic conductivity. However, insofar as we know, in spite of the fact that the question of surface waves was raised a number of times in the literature [1 - 3], no waves were observed earlier in a magnetoactive plasma with the properties described above. Therefore a further study of these waves is of undoubted interest.

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RECORDING OF OPTICAL INFORMATION ON AMORPHOUS FILMS OF SEMICONDUCTING COMPOUNDS

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At the present time optical methods of recording and processing information are among the most timely scientific and technical problems. Their extensive introduction, however, depends in many respects on the availability of media for recording the signal, and the choice of these, especially for the IR band, is limited.

We have realized experimentally a new method of optical information, based on the local variation of the structural and optical characteristics of certain semiconducting compounds under the influence of laser radiation. This uncovers a possibility of producing media with a large recording speed ($10^{-4} - 10^{-5}$ sec) and with large spatial resolution, requiring in addition no further processing.

When powerful light pulses act on thin amorphous semiconducting films, the crystallites in the films grow, and this is accompanied by an appreciable increase in their electric conductivity and reflectance in the IR region. A study of the kinetics of the phase transition from the amorphous to the polycrystalline one has shown that this transition can be effected within a time on the order of 10^4 sec at a definite activation energy of this process [1].

In our experiments, the media for the recording of optical signals were amorphous GeTe and InSb films sputtered in vacuum on glass and NaCl substrates. The experimental setup was as follows. A laser beam was split with a semitransparent mirror into two beams of approximately equal intensity and aimed at the sample at a convergence angle $\sim 55°$ for GeTe and $\sim 25°$ for InSb. This produced on the film an interference grating - a halogram of the radiation field. The samples were subjected to the action of radiation pulses of a ruby ($\lambda = 0.69\ \mu$)