INTERACTION OF SURFACE MAGNETOSTATIC WAVES WITH CARRIERS ON A FERRITE-SEMICONDUCTOR INTERFACE

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It was shown theoretically (in the works of A.I. Akhiezer, V.G. Bar'yakhtar, S.V. Peletminskii, E. Schlomann, W. Wural, and S. Kaliski) that the oscillations of the magnetic moment can interact with carriers both inside ferromagnetic semiconductors and on the interface of a ferrite with a semiconductor.

Such an interaction between volume magnetostatic (spin) waves and carriers was observed in a number of experiments and led to amplification or absorption of the magnetostatic (spin) waves [1 - 4].

We report here for the first time the results of an experimental investigation of the interaction of surface magnetostatic waves (SMW) with a drift current of electrons (amplification or absorption of SMW) in a system of two plates in contact. This system consisted of polished plates of yttrium iron garnet (saturation magnetization $4\pi M_0$ = 1770 G, width of resonance line $\Delta H < 0.5$ Oe, dimensions 10 × 5 × 1 mm) and germanium (electron density $n \sim 10^{14}$ cm^{-3}, mobility $\mu \sim 3600$ cm^2/V-sec at room temperature; dimensions 3 × 3 × 0.24 mm).

In such a system it is possible to have a delay of an electromagnetic signal propagating in an inhomogeneous internal magnetic field existing inside the ferrite plate, in the form of a surface magnetostatic wave. The behavior of the delayed electromagnetic signal permits a study of the interaction of surface magnetostatic waves with the carriers.

The contacting plates were placed in a delay-line model cooled with nitrogen vapor. The excited surface magnetostatic wave had a frequency f = 2 GHz and a pulse duration τ = 0.1 μsec. The constant magnetic field was applied perpendicular to the propagation of the SMW and parallel to the plane of the ferrite plate.

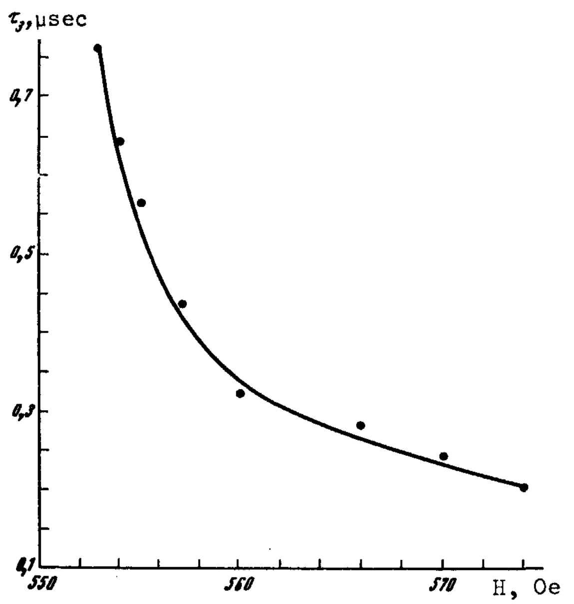

Fig. 1. Delay time of surface magnetostatic wave vs. magnetic field.

Pulses of a constant electric field (drift field) of duration 0.8 μsec and repetition frequency 500 Hz, with adjustable amplitude, were applied to the semiconducting plate through ohmic contacts.

The dependence of the delay time of the electromagnetic signal on the constant magnetic field is shown in Fig. 1. The character of this dependence and the values of the magnetic fields show that SMW are indeed excited.

It has been observed that when the directions of the surface magnetostatic wave and of the electron drift coincide, at a definite amplitude of the drift field (i.e., at a definite electron drift velocity) and a definite synchronization of the drift-field and surface magnetostatic wave pulses, the signal becomes amplified by transfer of energy from

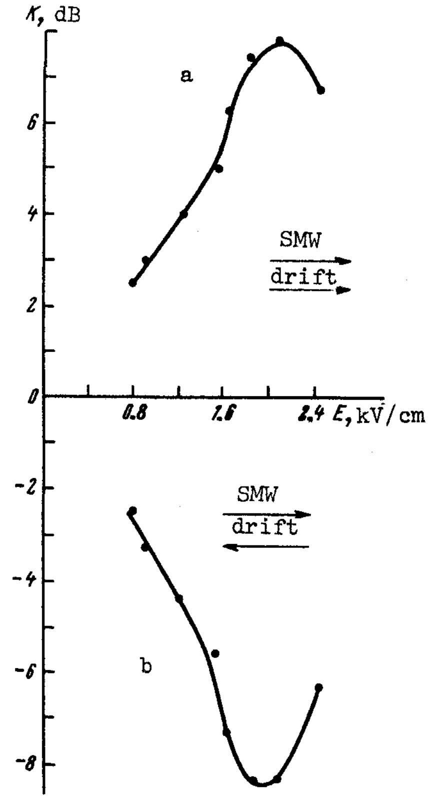

Fig. 2

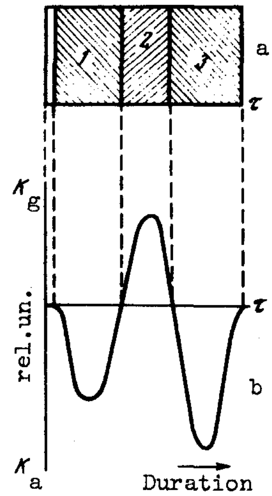

Fig. 3

Fig. 2. Gain and absorption coefficient of the surface magnetostatic wave vs. drift field at H = 555 Oe.

Fig. 3. Regions of absorption (1, 3) and amplification (2) of surface magnetostatic wave.

the electron current to the surface magnetostatic wave (Fig. 2a).

If the electron drift and the surface magnetostatic wave have opposite directions, the result is absorption of the signal by transfer of the wave energy to the electron current (Fig. 2b).

The surface magnetostatic wave gain (K_g) and the absorption coefficient (K_a) were measured by comparing the amplitudes of the delayed signal with and without a drift-field pulse. The maximum interaction between the wave and the carriers was observed at a drift field intensity on the order of 2 kV/cm.

The character of the interaction (amplification or absorption of the surface magnetostatic wave) should vary with the direction of the wave propagation and of the electron current (in the former case the directions are equal, in the latter they are opposite). If the electron drift is along the wave propagation direction, then the microwave magnetic field induces microwave currents in the semiconductor via the Hall effect. These microwave currents produce in turn in the ferrite microwave magnetic fields that maintain the precession of the magnetic moment. If the direction of the electron drift is reversed, the wave will attenuate, for the same reasons [5].

The amplification or absorption depends not only on the equality or inequality of the propagation directions of the interacting waves (at a definite ratio of the magnetostatic-surface-wave and electron-drift velocities), but also on the instant of time of the wave propagation at which the drift field is applied to the semiconductor. This is explained in Fig. 3. Figure 3a shows a drift-field pulse subdivided into three shaded regions (1, 2, 3) which characterize both the amplification (2) and the absorption (1, 3) of the wave, as illustrated by Fig. 3b (this figure pertains to the case when the wave propagation direction is the same as that of the electron drift). If the wave pulse (which is approximately one-eighth as long as the drift-field pulse) is located at region 1 or 3 of the drift-field pulse, then the wave is absorbed. The absorption in region 3 is larger by several decibels than in region 1. The amplification region is located between these two regions.

The wave gain can apparently be increased by producing molecular attraction between the contacting plates. There was no such attraction in our case.

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REGISTRATION OF DEBYEGRAM OF AMUMINUM COMPRESSED BY A SHOCK WAVE

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The possibility of using an x-ray pulse of duration $\sim 10^{-7} - 10^{-6}$ sec to register interference patterns of polycrystals has been demonstrated in [1 - 3], where data are also given on the efficacy of the means used to register soft x-rays when various types of x-ray sources are used. The noticeable recent progress in the development of this procedure make it suitable for x-ray structure investigation of substances compressed by shock waves.

We present here experimental results of the registration of an x-ray debyegram of aluminum compressed by a shock wave. We registered a section of the Debyegram with reflections from the atomic planes (111) and (200). We used K_αMo radiation (λ = 709 Å) and an exposure time $\sim 6 \times 10^{-7}$ sec. The x-rays reflected from the samples were registered with a high-sensitivity x-ray film with

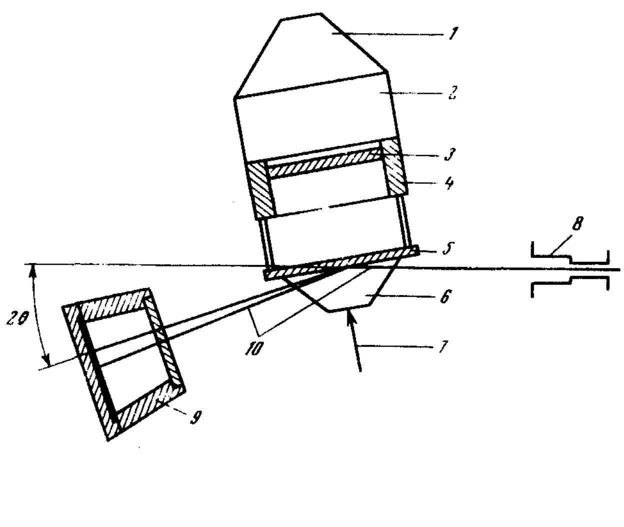

Fig. 1. Arrangement of apparatus for the registration of debyegrams of aluminum compressed by a shock wave: 1 - lens for producing a plane shock wave, 2 - explosive charge, 3 - aluminum striker, 4 - lead nozzle, 5 - investigated sample, 6 - lithium support plate, 7 - electric contact to record the instant when the shock wave emerges to the surface of the lithium plate and needed to synchronize the x-ray exposure with the required phase of dynamic loading of the sample, 8 - collimator, 9 - protected cassette with x-ray film, 10 - path of x-ray beam.