PHOTOACOUSTIC TRANSFORMATION IN NATURALLY GYROTROPIC MEDIA WITH OPPOSITE ELECTROMAGNETIC WAVES INTERACTION

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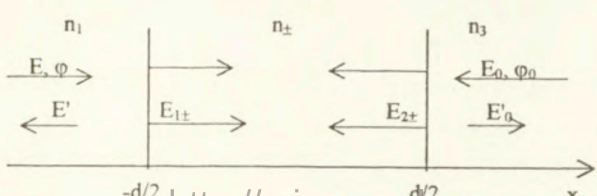
1. INTRODUCTION

The possibility of using the effect of the tunnel electromagnetic interference has been intensively studied recently. The effect is based on increasing of the electromagnetic wave transparence coefficient of Ti thin film if the opposite source is switched on [1]. The transparence coefficient depends nonlinearly on the intensity of the opposite source. That can be explained by a complex interference interaction inside the film. We can control interference flux of interaction waves changing the phase difference and opposite beams intensity ratio. That is an actual problem, which might allow decrease the energy losing.

2. THEORETICAL PART

The problem was considered by means of the following geometry: gas-sample-backing. Optical and heat properties for each material are known. On the thin isotropic naturally gyrotropic film, which borders on uniform isotropic media, two plane coherent monochromatic waves with the optical phase difference (ϕ-ϕ_0) are incident normally. Generally polarization of waves is elliptical.

Fig. 1. Scheme of opposite waves interaction in naturally gyrotropic media



We started considering border problem with the assumption that inside the film two waves, which are left right circularly polarized, propagate in opposite directions. Taking into account that continuity conditions of electrical field and induction of magnetic field vectors on the borders and material equations for gyrotropic media [2] are observed

$$\begin{cases} \vec{D} = \varepsilon\vec{E} + i\alpha\vec{H}, \\ \vec{B} = \mu\vec{H} - i\alpha\vec{E}. \end{cases} \tag{1}$$

We can determine waves amplitudes, propagating in the film. Using the material equations (1), the assumption that $\mu = 1$, energy dissipation was accounted.

$$Q = \frac{\omega}{4\pi}\left(A_+ e^{-a_+ x} + A_- e^{-a_- x} + A'_+ e^{a_+ x} + A'_- e^{a_- x}\right), \tag{2}$$

with

$$a_\pm = 2\frac{\omega}{c}\,\mathrm{Im}(n_\pm),$$

$$A_\pm = \left|E_{1\pm}\right|^2\left\{\varepsilon'' \pm 2\alpha''\,\mathrm{Re}(n_0)\right\},\ A'_\pm = \left|E_{2\pm}\right|^2\left\{\varepsilon'' \pm 2\alpha''\,\mathrm{Re}(n_0)\right\},$$

$$n_\pm = \sqrt{\varepsilon} \pm \alpha,\ \varepsilon = \varepsilon' + i\varepsilon'',\ \alpha = \alpha' + i\alpha'',\ n_0 = \frac{n_+ + n_-}{2},$$

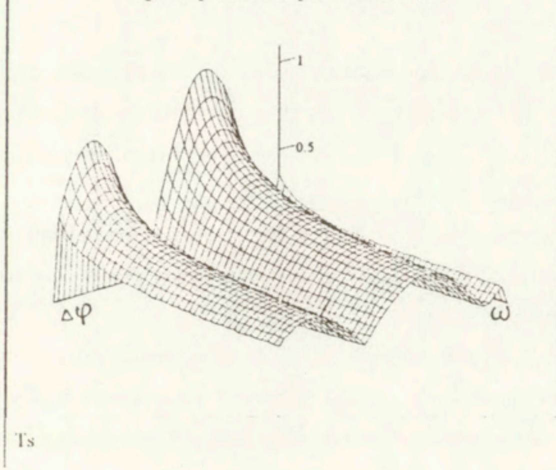
$n_\pm$ – refraction index for left- right circularly polarized waves, ε – dielectric permeability, ε'' – describes energy dissipation, α – parameter of gyrotropy, α'' – determines circular dichroism.

The temperature changing on the sample surface was found, for the sake of which the system of conductivity equations with using continuity conditions for the temperature and heat flux on the media border was used. Temperature changing depends on great number of parameters and physical constants. We don't consider time dependence of the resulting signal but use the transmission function method [3]. It allows us to rid of complex accounting in case of impulse influence, which is connected with the inverse Fourier transformation, and to conserve the general idea of our reasoning for harmonic excitation. Thus, the analysis of absolute meaning of transmission function, characterizing temperature changing on the research sample surface was done.

$$Ts(\omega) = \frac{1}{\left(b_- e^{-a_s d} - b_+ e^{a_s d} - g\left[b_+ e^{a_s d} - b_- e^{-a_s d}\right]\right)K_s}\left[\left(b_+ e^{a_s d} - b_- e^{-a_s d}\right)F\left(\tfrac{d}{2}\right) - \frac{1}{a_s}\left(F'\left(\tfrac{d}{2}\right) - Q_{\mathrm{int}}\left(\tfrac{d}{2}\right)\right)\left(b_+ e^{a_s d} + b_- e^{-a_s d}\right) - 2\left(bF\left(-\tfrac{d}{2}\right) - \frac{1}{a_s}\left(F'\left(-\tfrac{d}{2}\right) - Q_{\mathrm{int}}\left(-\tfrac{d}{2}\right)\right)\right)\right] \tag{3}$$

designate in (3) are the same as in [4]. Q_{int} appears only for the opposite wave interaction case, it includes of interference flux on the media borders.

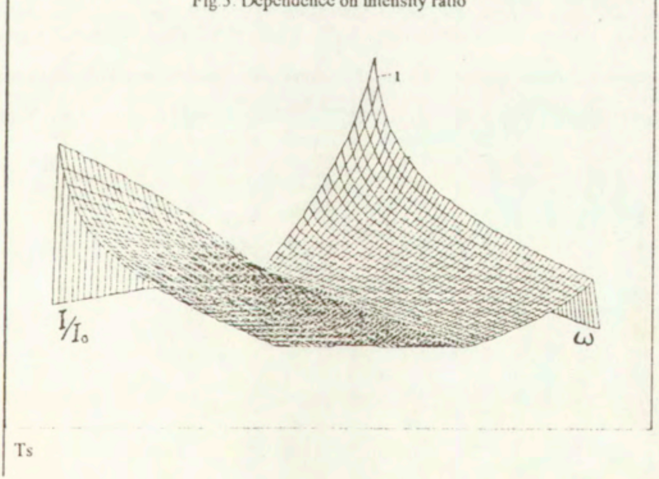
Fig.2. Dependence on phase differences



3. ANALYSIS OF RESULTS

Thin films with the thickness of about some waves were considered in that problem that dependent on the possibility to observe the tunnel electromagnetic interference effect. We consider that two linear one plane polarized electromagnetic waves interact.

Fig.3. Dependence on intensity ratio



The transmission function absolute analysis gives a periodical dependence of extreme succession on the interval $0 \div 2\pi$ on phases difference between opposite interaction waves (fig. 2). It can be explained by interference redistribution of the energy dissipation of interacting opposite waves in a sample volume.

Fig.3. shows the dependence |Ts| on the intensity of one of interaction beams can be local extreme explained redistribution of heat interference flux so that temperature changing on the sample surface is minimal.

In conclusion, we can suggest using phototermic transformation within opposite waves interaction as a nondestructive method of control because it is highly sensitive to phases difference of opposite waves. Also we wold have the possibility of the interference flux control and suppression of resulting phototermic signal.

REFERENCES

1. Sidorenkov V., Tolmatchev V. Effect of tune electromagnetic interference in metal films. Pisma v ZhTF. 1990. **16**. p. 20-25.

2. Fedorov F. Theory of gyrotropy. Minsk, Nauka i technika, 1976, 465 p.

3. Gusev V., Karabutov A. Laser optoacoustic. M., Nauka, 1991, 304 p.

4. Mityrich G., Zelyony V., Kozhushko V., Sviridova V. Photoacoustic transformation in gyrotropic media at tunnel electromagnetic interference conditions. Wspolczesna ceramica w osrodkach hyrotropowych w warunkach tunelowej interferencji electrycznej. Warszawa 1998.