FAST DETECTOR FOR THE POLARIZATION CHARACTERISTICS DETERMINATION OF THE PULSE IR-FIR LASER RADIATION

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Abstract. The fast detector for the time dynamic of the polarization plane location and the line polarized component power determination of the IR-FIR laser radiation is described.

Pulse powerfull IR-FIR tunable lasers have found use in several applications (spectroscopy of solids, plasma diagnostic and many others). The development of it requires the development of corresponding detectors with high time resolution and large dynamic range. The determination of the polarization plane location time dynamic may be pick out to the essential class. For the visible and near IR spectral range this problem is partly solved. In the IR-FIR range there are no methods of the pulse laser radiation polarization parameters measuring.

The paper describes the method and device based on its for the polarization characteristic determination. The definition is based on the ballistic photoelectric effects in semiconductors- photon drag effect (PDE) /1-3/ and linear photovoltaic effect (LPVE) /4-7/.

The photocurrent arises in the homogeneous semiconductors under the exitation by linearly polarized homogeneous radiation is described by the phenomenological formula /4/:

$$j_i = I\, T_{iklm} e_k e_l q_m + I\, P_{ikl} e_k e_l \qquad (1)$$

were I is the radiation intensity, e is the polarization vector, q is the light wave vector, T_{iklm} is the tensor of fourth rank determining PDE, P_{ikl} is the tensor of third runk determining LPVE. It may be noted that the photocurrent (1) is determined by the momentum relaxation times, which have a value about 10^{-12}–10^{-13}s.

The electric field E arises in the sample under the exitation by radiation in the unclouse circuit regime which can be described by equation:

$$\vec{j} - \sigma \vec{E} = 0$$

$$E_i = \Sigma \frac{T_{iklm}}{\sigma} q_k e_l e_m + \Sigma \frac{P_{ikl}}{\sigma} e_k e_l \quad (2)$$

were σ is the conductivity. This e.m.f. contains the information about polarization characteristics of the incidient radiation. There are such mutual orientations of the crystal, wave vector and electric contacts by which the measuring of the electric signal allows one to determine the polarization plane location.

The detector on the base of outlined effect is described (preliminary results were given in /7/). The polarization plane location analyzer has been constructed from the p-GaAs (Zn) monocrystal with the carrier density $p=2.3*10^{16} cm^{-3}$ and mobility $250\ cm^2V^{-1}s^{-1}$. It is a semiconductor plate (Fig.1) with a size 5*5 mm and thickness 2 mm. The plane is a (111) crystalographic plane. There are a 2 pairs of ohmical contacts along the directions [1$\bar{1}$0] and [11$\bar{2}$].

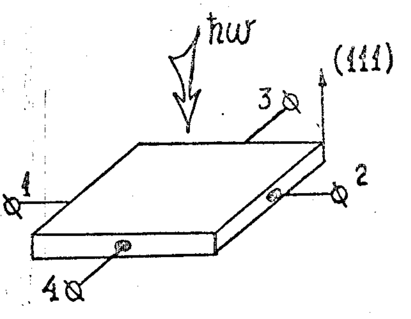

Figure 1.

In this case the e.m.f. signals V_1 and V_2 arise between the points 1-2 and 3-4 (Fig. 1) under the influence of the normalized incidiend radiation. It may be shown from (2) that the case of the crystal simmetric group T_d, it's value determined by equation:

$$V_1 = P_1\ A \sin(2\theta)$$
$$V_2 = P_1\ A \cos(2\theta) \quad (3)$$

were P_1 is the power of linearly polarized laser light contribution, θ is angle between polarization vector and [11$\bar{2}$] axis, A is the constant which defines the current.

It is easy seen from (3), that the simultaneous measuring of the signals V_1, V_2 gives the value of the angle θ , which determined the polarization plane location and the power of the linearly polarized component P_1. The time resolution of the and P_1 determination is about 10^{-12}-10^{-13} s, and depends from the bulk temperature and radiation wavelength.

The solution of this system is

$$\Theta = \frac{\pi}{4}(1-\text{sign}(V_2))\text{sign}(V_1) + \text{sign}(V_2)\frac{1}{2}\arcsin\frac{V_1}{\sqrt{V_1^2+V_2^2}}$$

$$P_1 = \frac{1}{A}\sqrt{V_1^2+V_2^2} \quad (4)$$

On the base of this detector element the new fast uncooled detector has been developed. It includes two differential amplifiers with bandwidth up to 70 MHz and the gain coefficient of 100. The detector can be used in the spectral range from 9 to 500 μm. The value of the A, which determines the detector sensitivity, is given in the tables. The time resolution of the detector (5 ns) is determined by the amplifiers bandwidth. The detector works at room temperature.

Table. The value of the detector element sensitivity A for a several wavelength.

Wavelength, μm	9.2	10.6	90.55	152	385
A, μV/W	0.37	0.5	0.21	0.21	0.24

It may be noted that the detector with the same characteristics has been designed and constracted on the base of the transverse PDE only. In this case, the detector element has been constracted from the p-Ge(Ga) monocrystal with carrier density $p=3*10^{14}$ cm^{-3}. The constraction of it was similar to the constraction of the described detector. The plane of the semiconductor plate was (111) crystalographic plane. In this case the values of the transvers photon drag signals are also determined by equation (3).

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