THE PHOTOCONDUCTIVE BGO - PLZT CERAMICS IMAGING SYSTEM WITH DEFORMATION DISPLACEMENT AND WORKING ON REFLECTION

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ABSTRACT

Features of Bi12GeO20 (BGO) photoconductor - PLZT ceramics system with use of deformation displacement and working on reflection are investigated. Properties of BGO film, increasing sensitivity of the given system in 10^4 times, are in detail considered. Advantages and lacks of the given system are shown.

Keywords: photoconductor, deformation, reflection, ceramics, films.

I. INTRODUCTION.

As it was specified earlier, irrespective of type photoconductive films, in devices of record and display of the information, using PLZT ceramics with deformation displacement and working on transmission, for achievement of the maximal contrast of the image and a minimum of optical losses on absorption to receive half-wave change of a difference of phases at optimum thickness of a ceramic plate it is practically impossible [1-5]. Therefore in real breadboard models of the given devices optical losses on absorption of the device turn out more, and the coefficient of contrast is less, than what could be received with the help of the device having full half-wave change of a difference of phases. One of ways of reception of full half-wave change of a difference of phase (λ/2 - change) the device, is its use in a mode of reflection.

II. MAIN PART

The general circuit of the device working on reflection, is submitted on fig. 1 [3]. Apparently, the given circuit from the circuit resulted in [1-3] and working on transmission, differs only addition of a matrix of the metal reflecting electrodes placed in optically the opaque environment between a ceramic plate and photoconductive film. It would be note, that as against such classical devices where as a photoconductive films (PCF) were used the PVC, CdS, $Cd_xZn_{1-x}S$ films, etc. [2, 3], in our case use the bismuth germanium oxide $Bi_{12}GeO_{20}$ (BGO) as a photoconductive film in the given devices has allowed to increase sensitivity of researched system 10^4 times, that from the practical point of view is extremely important factor.

Reception and properties of photoconductive film. BGO films sputters on a metal matrix by magnetron dispersion with the subsequent annealing on air. Thickness received films is in order of (2 ÷ 8) micron. For reduction of a roughness of the surface, received films were exposed to polishing and polishing by diamond paste with corresponding cleaning in the subsequent.

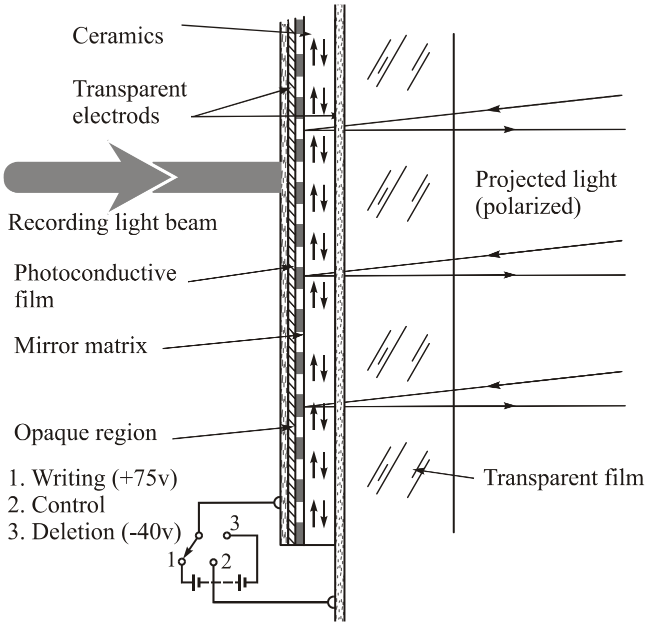

Fig.1. A circuit of the device based on deformation displacement and reflection working in a mode.

We shall consider volt - ampere characteristic (VACH) of BGO films, having great value at redistribution of a voltage in researched structure. For research VACH and transmission coefficients BGO films were sputters on quartz substrates. For measurement VACH the Ag, Al, In - Sn electrodes have been used.

Measurements of VACH in structure Ag-BGO-Ag (without ceramics) have shown, that dark VACH of high-resistance BGO films and its dependences on various factors down to intensity of field E = 10^6 V/м, had close to linear sublinear dependence. Further the tendency to increase in a degree of the characteristic of VACH (a curve 1, fig. 2a) was observed. At illumination of BGO films by light from the region of their photosensitivity (h ν =1÷ 4.5) eV, since some values of intensity of light (J ≥ 10^{-7} Vt/sm^2), in VACH characteristic of BGO films are observed nonlinearity. On fig. 2a are submitted typical VACH, measured in structure Ag-BGO-Ag at illumination of BGO films by cyan light of various intensity. Temperature of measurement is 300K, thickness of a sample is 8 microns.

Observable VACH can be broken into four sites: 1-an initial, linear (ohmic) site; 2-on a site, where a voltage of sample U_1 <U <U_2 - sublinear (in some samples of films and in the majority of BGO crystals on the given site the root dependence $I_{ph}=U^{1/2}$ was precisely observed); 3-at voltage U> U_2 - superlinear, the slope in which in the beginning grows, then smoothly decreasing, comes nearer to linear; and 4-at voltage U> 1V - again ohmic. The greatest interval of the top ohmic site have the structures with In - Sn contacts. The current in the field of superlinear VACH is normalized in coordinates $I_{ph} = U^{1/4}$.

Researches have shown, that character VACH in Me-BGO-Me structure, where Me = Ag, Al, In, at its illumination as own, and impurity light, did not depend on polarity of a voltage on the covered electrode. It is necessary to note, that similar VACH with characteristic sites were observed and in high-resistance film samples and crystals $Bi_{12}SiO_{20}$ (BSO) and $Bi_{12}TiO_{20}$ (BTO) at their illumination, and in low-resistance samples without illumination.

A transition of sample to low-resistance state, equal to the ratio of resistance of a sample on a sublinear site-2 to its resistance on the top ohmic site-4 ($U_2/I_{ph2}/U_4/I_{ph4}$), at increase of intensity of illumination increases proportionally to the logarithm of intensity of light. The greatest rate is observed at cyan (blue-green) illumination (1÷ 4.5) eV. The rate of switching K_v of the sample, determined at cyan illumination, decreases, if a film (or a crystal) is illuminated by proper (> 3 eV) or red (1eV ≤ h ν ≤ 2eV) light beam.

The voltage U_2 for the beginning superlinear VACH for own and cyan illumination coincide, and for red illumination it is a little bit more. At increase in temperature K_v decreases, U_2 grows (U_2 ~ T), and U_1 remains constant. We shall note, that temperature dependence of parameters K_v, U_1 and U_2 it is similar for all crystals investigated by us. The researches which have been carried out on samples of various thickness, have shown, that with other things being equal, the rate of switching K_v is inversely proportional to thickness of a sample (K_v ~ 1/d). And, U_1 and U_2 from thickness of samples do not depend.

Lux-ampere characteristics (LACH) measured on the top ohmic site, are linear, and at voltages from a site- 2 - LACH is sublinear with a degree close to 0.7 (fig. 2b). It is established, that U_1 and U_2 from illumination intensity do not depend.

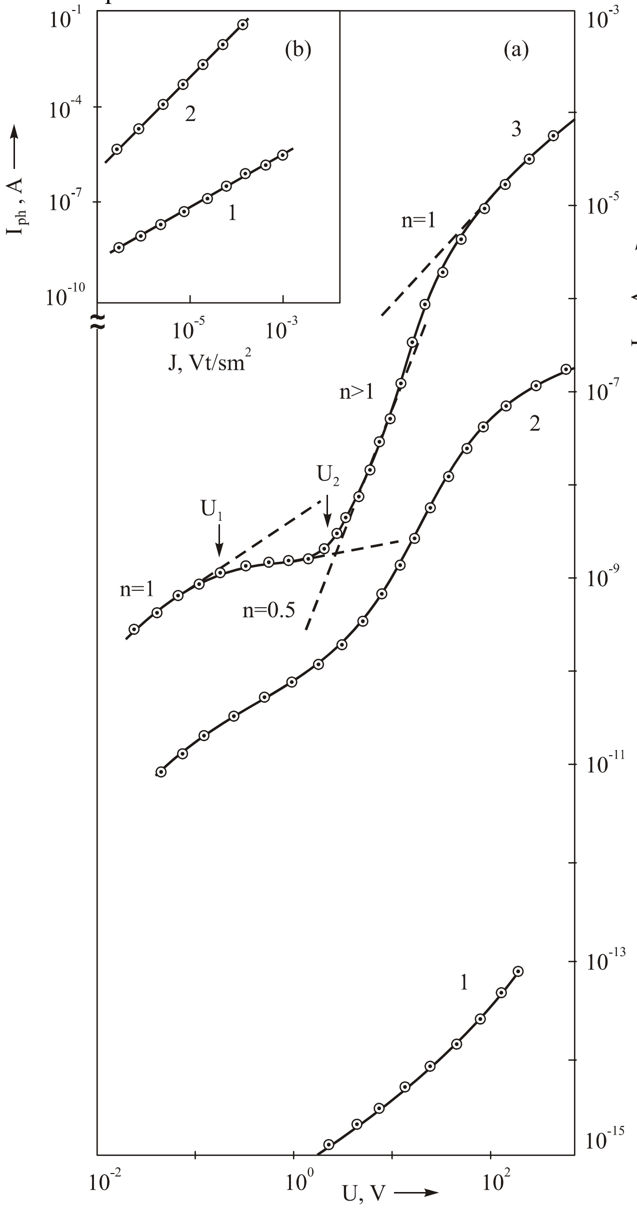

Fig.2. Volt- ampere characteristic (VACH) (a) and LACH (b) in structure of Ag-BGO-Ag: a) VACH in darkness (1) and at intensity of illumination:2·10^{-4} Vт/sm2 (2),1·10^{-2} Vт/sm2 (3); b) LACH at voltage 0.8 V(1) and 100 V(2). Thickness of a sample is 8 microns; T = 300K; spectral region of illumination (2.1 ÷ 2.6) eV.

Let's consider now some features of the characteristic of the device.

Characteristics of quality of the device. It would be note, that the device working on reflection, has three basic advantages in comparison with the devices working on transmission [2-4]: a) a higher resolution in view of use of more thin ceramic plates for reception of change of a difference of the phases, equal $\lambda/2$; b) independence of reading and writing light is provided with the opaque environment; c) projected light does not pass through photoconductive film, the potential source of loss of light thus is excluded. Thus, there is full freedom of a choice of a photoconductor. It can be absolutely opaque to projected light. From this point of view there is a prospect of use of the given devices in quality IR- converters of light.

The measured optical losses on absorption it is caused by the several reasons: a) losses at reflection from metal films; b) losses of light in backlashes between reflecting Al elements (using silver and having elements on closer distance, they can be reduced almost three times); c) losses on absorption in a ceramic plate; d) losses in a polarizer and in the semi-transparent mirror used for division of light falling and reflected from the device. The mentioned above losses can be reduced in the various ways (for example, use of a polarizing prism and a polarizing beam splitter [3] essentially reduces these losses).

Record and supervision of the written down image. We shall consider record of the image on the real device with the account of BGO photoconductive film. As shows experience, it is the best way to begin record of the image, having taken the ceramics, taking place L-state (domains are in a plane of the plate). Thus it's her separate sites illuminated with light, are switched to T-state (domains are perpendicular planes of the plate). At concentration La equal to 8 %, for switching the covered sites from L - to the T-state for the given thickness of a sample 75 microns are required a pulse of the voltage, approximately equal 75B. Record can be carried out displaying of the image on a ceramic plate, or with the help of display of a beam or with the help of the device for a contact seal.

Deleting the written down image. To carry out deleting the image, it is necessary to apply on electrodes a voltage of the order of 100B that is equivalent to returning of all plate in L- state. Switching is most simply reached by illumination of BGO photoconductive film covering all ceramic plate, light from own absorption region during time of the voltage applied. It is necessary to note one important feature of such devices, consisting that, despite of presence in them only two having clips to erase the image in such devices there is no necessity. One of advantages of such devices is its work in a mode of periodic increase in the switching voltage, allowing for write or erase the image depending on position of the switch of a voltage only in the separate sites illuminated by a light beam. Having divided a matrix of the device with discrete matrix structure of electrodes on a line and using electronic control for selection of lines, it is possible to reach good results. Thus, in the device using deformation displacement, with the help of writing down light beam it is possible to carry out addressing and to change only one element of the image.

The resolution. For a ceramic plate thickness 75 microns the highest resolution does not exceed 75lines/mm. At such limit of the full cycle of change from bright up to a dark site occurs in distance of 15 microns. As the size of grains of ceramics is equal 1-2 microns, apparently, they do not limit the resolution of the device. On the contrary, hold the opinion that the basic restriction, overlay on the resolution of a ceramic material, bring in the fringes arising at partial reflections of reading light from borders of layers. Thus, the resolution of the device is limited not to a ceramic plate, but the matrix of elements consisting in this case from 50 metal elements on 1см. Change of a difference of the phases, received in the device at switching from position "switch on" to position "turn off" (λ=545 nanometers), was approximately equaled $\lambda/2$. The low contrast observed at displaying of the image is determined apparently by light depolarization at dispersion of light in a ceramic plate.

For a choice of optimum thickness of the ceramics corresponding to the maximal resolution of the device, it is necessary to investigate dependence of resolution on thickness of ceramics. The resolution of the device depends not only on thickness of a plate, but also from the concrete nature of the deformation caused by the enclosed pressure. For example, the device working on compression has more isotropic resolution, than the device working on a stretching. It would be note, that the theory quantitatively describing observable anisotropy of the resolution, it is not created yet. However the experimental works spent for this region allow for assume that the given effect can be shown by an optimum combination of geometry and deformation displacement to a minimum [2, 4].

Sensitivity and frequency of operation. It is known, that for record of the image on ceramics at time of an exposition 1 second in the experimental samples using PVC films as photoconductive material, the light intensity about 10мВт/sm^2 [2] .This rather big density of energy and small speed of operation is required are caused by characteristics of photoconductive PVC films.

III. CONCLUSION

Use thin BGO films as a photoconductive layer, allows to increase sensitivity of the device almost by order of four (10^4 times) and to finish capacity of an exposed light beam up to 1мкВ/sm^2. As the photoresponse time in the field of proper absorption of BGO films is less than 10nsec [6], and process of switching of domains in ceramics can last some micro seconds frequency of operation of such devices will be limited to time of switching of these domains.

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