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APPLICATION OF A SENSOR ON THE HETEROJUNCTION CdS-Cu_2S BASIS

A novel image sensor has been developed for measuring weak optical signals. The optical information is stored as the charge of the non-equilibrium carriers trapped in the space-charge region of the heterojunction. In the visible range of the spectrum a response of 10^{-6} lx is achieved. In this work the opportunity to obtain the image in X-ray beams was investigated. It is established that investigated sensor is sensitive to soft X-ray radiation. Memory and accumulation of a signal at a room temperature, which is characteristic of the sensor at registration of images in visible beams, take place for the images obtained in X-ray range, too, that makes it possible to apply such sensor in medicine and in crystallography.

We have fabricated and investigated a novel sensor based on the non-additive formation of current [1]. The special properties of this novel sensor are an ability for long-term signal storage at room temperature and the large area of the operating surface. Even the first fabricated samples have an imaging area of 10 cm^2, which exceeds the area of typical CCDs by a factor of 15-20. For example, the imaging area of the TC 241 CD camera (Texas Instruments) is 8.6 mm × 6.5 mm.

It was established that there is no image-signal smearing with time and this quality is based upon the principle of image formation. The latent image in the sensor has been formed by the non-equilibrium charge trapped in the deep levels at the interface of the heterojunction. This permits a time-stable image to be obtained with the sensor.

Experimental curves that characterize the process of signal storage at room temperature for various levels of illumination of the heterojunction surface has been obtained. Such dependencies are well known for photographic emulsions. It should be noted that the applied bias is zero during the exposure. Before the adsorption of the photons the system is in equilibrium and it can be in this state for any period of time. Therefore, under minimum illumination levels the signal increase is not distorted by thermally generated carriers.The good stability of the latent image signal and, therefore, its ability for prolonged storage has been determined.

The sensor was based on a CdS-Cu_2S heterojunction. A thin-film sandwich arrangement is deposited by vacuum evaporation on a glass substrate. A thin Cu film and a transparent conducting $Sn0_2$ layer provide the integral contacts to the p- and n-sides of the heterojunction, respectively. A 256 level video-signal readout is obtained by scanning the surface of the sensor with a point IR probe. Our computer set-up provides the output data in two formats: 128x128 pixels with 16 grey levels and 250x250 pixels with 32 grey levels.

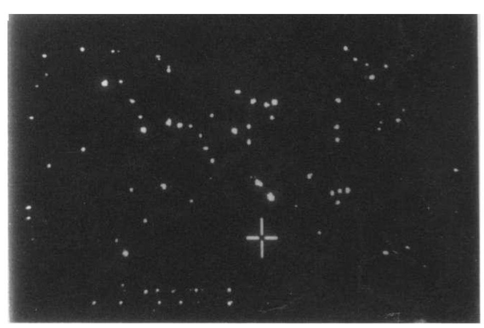

FIG. 1. Image of artificial stars given by the sensor (250x250 pixels)

The spatial resolution is also an important feature of image sensors. The theoretical analysis of the resolution of the detector gives a value of about 1 µm. We have not been able to focus a light spot within such small dimensions. For visible light, the maximum measured spatial resolution is 2-3 µm. Such a high resolution is obtained because of the small lifetime of the minority non-equilibrium current carriers in non-ideal heterojunctions and, consequently, their very small diffusion length. Experimental data for the sensor are listed in Table 1. Fig. 1 represents an image of artificial stars produced by the sensor. High resolution of point objects is seen in the case of an image shape of 250x250 pixels.

Parameters of the detector, based on a non-ideal heterojunction

Imaging area	50 mm×30 mm
Maximum of sensitivity	10^{-6} lx
Spatial resolution	<50 µm
Maximum period of signal storage	2 h

It is known that the effect of X-rays, like visible beams, leads to appearance of non-equilibrium carriers and it can be used to obtain images in X-rays. In this case, as in [2,3], image, in fact, should be shaped by non-equilibrium positive charge, captured at hole traps in space charge area of cadmium sulphide. So, there are the reasons to suppose that it shall have the same properties like the images obtained in the visible range of spectrum. At the same time, it is known that operating sensors of X-ray radiation have the thickness of sensitive absorbing layer not less than 100 µm. And it should not forget that cadmium as component absorbs X-rays successfully. But, the thickness of cadmium sulphide layer, obtained by electro-hydro-dynamic spray of liquid, is not more than 10 (im, so the problem to use the given transducer in X-ray range leaves open.

To clear up this problem we use the sample, in which the layer of cadmium sulphide was obtained by the above mentioned procedure. Medical plant, giving soft X-ray radiation, was used as a source. The doze obtained by means of this plant was not more than 100 millirentgen. As the test-subject, which partially screened X-ray radiation, we used the absorbing wedge consisted of aluminium foil strips with thickness of 100 (µm each. After exposure the sample was scanned, and the shadow of wedge with increasing density being clearly seen on the obtained image. It shows the principal possibility to indicate X-ray images.

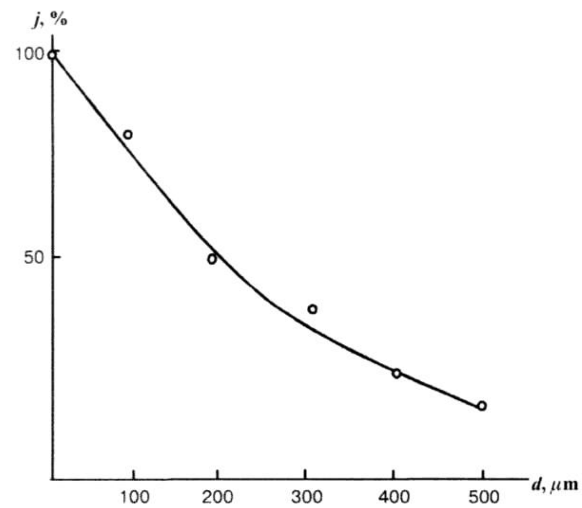

FIG. 2. Dependence of video-signal amplitude on the thickness of absorbing layer

Fig. 2 shows the curve for dependence of photo- response on thickness of absorbing layer d, which is different for various wedge parts. It is seen clearly that signal value falls exponentially under increase of absorbing layer thickness. It is seen that absorbing layer reduce signal in ratio 1.37. Exponential shape of curve indicates good linearity for dependence of signal on doze of X-ray radiation (because increase of absorbing layer thickness by stated value always leads to the same drop in signal level). It is clearly seen from Fig. 3.

Besides, since the signal being used to construct the plot was taken from different surface points, the obtained curve indicates the sufficient homogeneity of sensitivity to X-rays along the surface.

To investigate the abilities of the sample to be used as sensor of X-ray image, the ordinary IC with standard plastic package was taken. Under the repeated scanning, which was carried out in 30 minutes after the foregoing one, it was found out that in this case there was no spread too, and the quality of image remained satisfactory, despite the signal relaxation in time. So, the positive properties, such as memory and signal accumulation characteristic of our sensor under image indication in visible beam, take place for the images obtained in X-ray range.

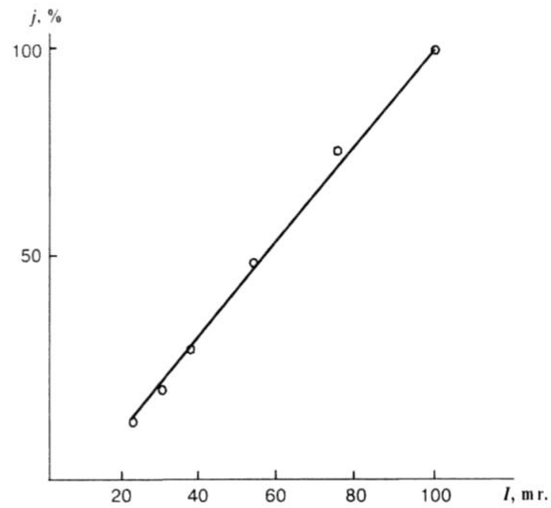

FIG. 3. Dependence of video-signal amplitude on the doze of incident X- ray radiation

So, resting on the above described investigation, one can say with certainty, that our sensor is sensitive to soft X-ray radiation. This makes possible to use such sensor in medicine, and also in crystallography.

Summarizing the main properties of the novel image sensor, we conclude that the detector is также very suitable for applications in astronomy. The use of adaptive optics with astronomical instruments allows the influence of atmospheric turbulence to be decreased. In these conditions an increase of exposure increases the power of the telescope-sensor system that is necessary for the imaging of faint objects, such as galaxies. The use of the sensor to obtain large-format electronic photographs of subtle lunar and planetary details with high resolution is also of great interest. In our first astronomical experiment [4] we obtained a lunar image as well as an image of 5-magnitude (5^m) stars. The future applications of the novel sensor are associated with the possibility of high-quality long-term image processing by means of active and adaptive optics.

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APPLICATION OF A SENSOR ON THE HETEROJUNCTION $CdS\text{-}Cu_2S$ BASIS

Abstract

A novel image sensor has been developed for measuring weak optical signals. The optical information is stored as the charge of the non-equilibrium carriers trapped in the space-charge region of the heterojunction. In the visible range of the spectrum a response of 10^{-6} lx is achieved. In this work the opportunity to obtain the image in X-ray beams was investigated. It is established that investigated sensor is sensitive to soft X-ray radiation. Memory and accumulation of a signal at a room temperature, which is characteristic of the sensor at registration of images in visible beams, take place for the images obtained in X-ray range, too, that makes it possible to apply such sensor in medicine and in crystallography.

Keywords: astronomy, heterojunction, image sensor, X-ray image.

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ВИКОРИСТАННЯ СЕНСОРА НА ОСНОВІ ГЕТЕРОПЕРЕХОДУ $CdS\text{-}Cu_2S$

Резюме

Був розроблений новий сенсор зображення для слабких оптичних сигналів. Оптична інформації зберігається у вигляді нерівноважного заряду локалізованого на пастках в області просторового заряду гетеропереходу. У видимій області спектру чутливість досягає 10^{-6} лк. У роботі також показана можливість отримання зображення в рентгенівській області. Встановлено, що сенсор чутливий до м'якого рентгенівського випромінювання. Ефекти пам'яті і накопичення сигналу при кімнатній температурі, що є характерним для датчика при реєстрації зображень у видимих променях, притаманні йому і при реєстрації зображень в рентгенівському діапазоні, що робить можливим застосування таких датчиків в медицині і в кристалографії.

Ключові слова: астрономія, гетероперехід, сенсор зображення, рентгенівських сенсор

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ПРИМЕНЕНИЕ СЕНСОРА НА ОСНОВЕ ГЕТЕРОПЕРЕХОДА $CdS\text{-}Cu_2S$

Резюме

Был разработан новый сенсор изображения для слабых оптических сигналов. Оптическая информации хранится в виде неравновесного заряда локализованного на ловушках в области пространственного заряда гетероперехода. В видимой области спектра чувствительность достигает 10^{-6} лк. В работе также показана возможность получения изображение в рентгеновской области. Установлено, что сенсор чувствителен к мягкому рентгеновскому излучению. Эффекты памяти и накопления сигнала при комнатной температуре, что является характерным для датчика при регистрации изображений в видимых лучах, присущи ему и при регистрации изображений в рентгеновском диапазоне, что делает возможным применение таких датчиков в медицине и в кристаллографии.

Ключевые слова: астрономия, гетеропереход, сенсор изображения, рентгеновский сенсор.