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PHOTOSENSORS WITH Si—GaAs HETEROJUNCTION AS MEMORY ELEMENTS

The photosensors with non-ideal heterojunction, prepared by special technique, have property of anode voltage independent accumulation and memory. The regularity of structure switching was found in dependence on intensity and duration of light signal. The mechanism of memory effects is proposed. The possibility of creating of energy independent memory devices is shown.

In this paper the realization of possibility creation p^+(Si)—n(Si)—p(Si)—n^+(GaAs) photoheterothyristors with memory effect is presented. The principle of operation of these devices allows to exclude negative influence of defects on interface of heterojunction and even to use them [1].

The structures of the devices were made on the base of n-Si substrates. On one side of n-Si wafer with the help of diffusion method a homojunction was produced. On the other side the GaAs layer was grown with the help of LPE method by special technology. Additional n(Si)—p(Si) homojunction was formed during the epitaxy process.

Current voltage characteristic of grown structures with region of negative differential resistance was able to vary under action of light impulse [2]. During the illumination of the structure, the switching voltage reduced. Independently on the anode voltage such feature of current voltage characteristics was kept some time at darkness after the light signal was switched off.

Every next switching of this structure occurred at voltage smaller then the first switching voltage at darkness. Such ability of the device was preserved certain time dependent on duration of preliminary illumination. On fig. 1 the curves verifying this dependence are shown. The regularity of a course of curves is that with increase in time of structure illumination the time of U_1 switching voltage relaxation increased. The change of light intensity from 500 up to 5000 *lux* results in increase of storage time.

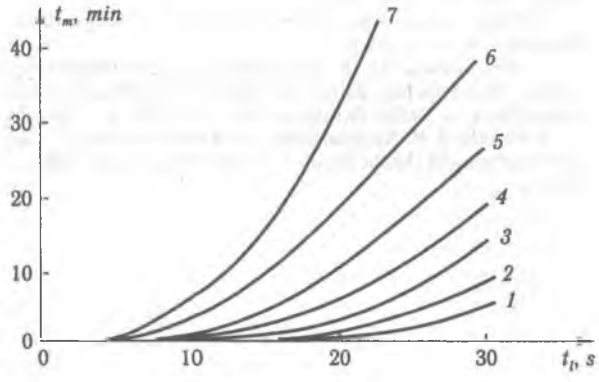

Fig. 1. The dependence of «memory» time on duration switching of four-layered structure at different intensities of illumination:

1 — 500, *2* — 1000, *3* — 2000, *4* — 3000, *5* — 4000, *6* — 4500, *7* — 5000 *lux*

It was established, that the voltage of dark switching decreases with increase of time and intensity for preliminary illumination of photoheterothyristors (fig. 2). Therefore, the laws of dark switching voltage recovery versus time and intensity of illumination coincide qualitatively.

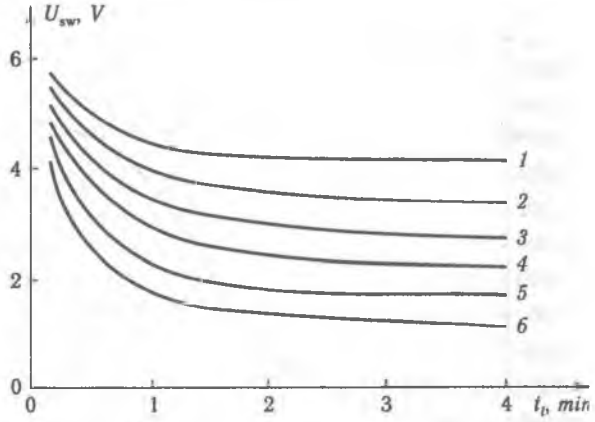

Fig. 2. The dependence of switching voltage on duration of illumination at different intensities of lighting:

1 — 500, *2* — 1000, *3* — 2000, *4* — 3000, *5* — 4000, *6* — 5000 *lux*

The memory ability was estimated by drift of the switching voltage U_{sw} after lighting the sample at different temperatures and without voltage during operation of a light signal. The drift of voltage U_{sw} at zero shifts in the course of lighting was investigated in the interval of temperatures 253...303 K. At lower temperatures the switching voltage shifts to the area of large voltage where measurements are difficult.

Dark switching voltage was determined at each stated temperature from a current—voltage characteristics. After that the sample was lighting during 3 minutes (maximum illumination). During this time current—voltage characteristics of structure was

measured several times and the drift of switching voltage (fig. 3) was observed. After the light was

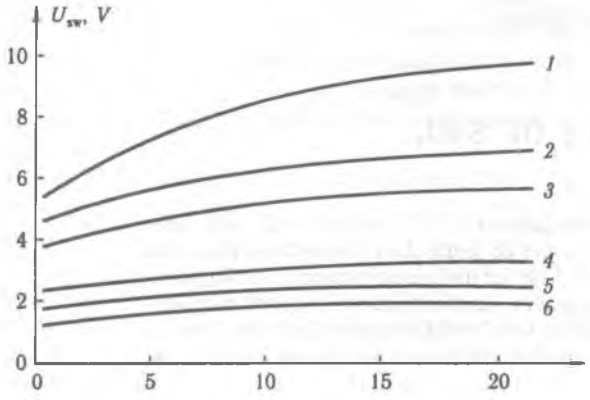

Fig. 3. Drift of switching voltage after the illumination of structure for different temperatures:
1 — 253, *2* — 263, *3* — 273, *4* — 283, *5* — 293, *6* — 303 K

switched off, the voltage U_{sw} was less, than before illumination. However, in the course of time it increased up to large values. It was established that at low temperatures (fig. 3) relaxation U_{sw} was longer, than at high temperature. Full relaxation of switching voltage for different specimens occurred 24 hours to several month. The researches carried out allows to establish the dependence of temporary drift U_{sw} upon temperature and previous history of specimens. The time constant of a relaxation τ was determined. At low temperatures of measurement the value τ changes from 2 up to 4 min correspondingly and at higher heats (283...303 K) a time constant $\tau = 5$ *min*.

All observable effects can be stipulated by fact that after switching off *p—n—p—n* of structure the charge of exuberant carriers in bases does not disappeared completely. There is a non-equilibrium charge, which is less than threshold charge, necessary for switching, but which makes easy the switching of the device by a next impulse.

The effect of storage, which photoheterothyristors have, can be connected with trap centres with a large relaxation time. In our case such centers are the broken off bounds, which are formed by mismatch dislocations in a boundary layer of heterojunction. The concentration of trap centres amounted $N = 2{,}5 \cdot 10^{14}$ cm^{-2}. The memory effect is grounded on the change of a charge condition of trap centres under action of incident light. The similar effects were observed in heterostructures on the basis of other «nonideal» heterojunctions, for example, ZnTe—ZnSe.

The ability of photoheterothyristors to accumulate and to store the information allows to create on their base highly sensitive memory devices, independent of voltage.

References

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