INFLUENCE OF THE RADIATION ON ELECTROPHYSICAL PROPERTIES OF DIODE STRUCTURE

H.K. Akberov

Institute of Physics of Azerbaijan Academy of Sciences.
AZ1143, Baku, Azerbaijan, H.Javid av 33 , Fax (99412)395961,

ABSTRACT

By irradiation exposure on p-n junctions by the presence of reverse shift-the conductivity change is due to the carrier generation within space charge. i.e. radiation conductivity of p-n junctions is due mainly to the formation of electron-hole pairs in space charge.

Keywords: radiation, diode structure, p-n junction, electron-hole pair, photoconvertor.

I. INTRODUCTION

From radiation research one should note such specific features of Se p-n junctions as high radiation stability and small radiation-induced conductivity. As photoconverters selenium heterojunctions are characteristic of spectral sensitivity close to the human's eye sensitivity.

The results of work [1] points to that fact that by Si crystal exposure there has been taken place significant change of lifetime of minor charge carriers.

In work [2] current obtained results on SiC radiation stability investigations and development of nuclear irradiation detectors on charge carrier concentration and recombination processes in silicon carbide have been analyzed. By radiation stability we mean unchangeability of semiconductor or semiconductive device parameters at their irradiation.

At SiC investigation exposed to radiation by electrons with energy over the range (3,5-4)MeV in the band gap deep center levels have been found.

In [3] there has been investigated the influence of electron irradiation on the donor formation in Si. Carrier concentration rises with the irradiation doze increase. Concentration increase in separate regions can be due to the nucleation center increase created by radiation defects.

II. MAIN TEXT

To obtain new information about the features of Se photocells by electron diffractometry we investigate contact layer structures with some metals (Cd-In, Pb.Ga,Hg). It is established that in near-contact layer there have been formed corresponding selenides are formed: CdSe, ZnSe, PlS, GaSe, HgSe.

It is show that to create effective p-n heterostructures CdSe and CdS are the best n-materials. Photocells with CdSe, CdS layers have the sensitivity 700-750 mkA/lm. At solar radiation 100 mBT/cm^2 emF 0,6-0,7V, photocurrent 2÷2,5 mA/cm^2 have been generated.

This paper deals with the investigation results of energy homogenous electron influence on p-n junctions. The source of accelerated electrons is the linear electron accelerator. At the energy of accelerated electrons 5 MeV (current density of electron beam 1,5 mkA/cm^2) for 5 minute irradiation the values of U_{LR} and J_{SC} for Si and Ge diodes decrease comparatively with the initial ones by 3-5 times under the same conditions for Se diodes sensitivity loss is within 20-30%. For example after 24 hour exposure radiation sensitivity of Se diodes are restored completely that are not observed for Si and Ge devices. Sensitivity loss of investigated Ge and Si devices appears to be the consequence of structural defect formation

Se diodes with halogen impurity comparing with halogen-free elements having as little as 1,5-2 sensitivity are of big radiation stability. For example at 5 MeV (1,5mkA/cm^2) for 5 minute exposure the loss of radiation sensitivity of halogen-free elements is 20÷30% and for elements with Cl impurity is 10÷20%.

In Fig. there have been presented static VAC of one of the Se-CdS samples before and during exposure by 1 MeV. Radiation sensitivity of forward direction is due to the change of Se and CdS specific receptivity. By irradiation effect on diode with the reverse shift conductivity change depends mainly on carrier generation within space charge, i.e. radiation.

Conductivity for our diodes depends mainly on the formation of electron-hole pairs within space charge. By irradiation capacity increase depends on the density increase of space charge on $N=2{,}5\cdot10^{16}$ cm^3 up to $N=3{,}8\cdot10^{16}$ cm^3.

After the investigated p-n structure irradiation C-V characteristic shift upwords in Y-axis maintining the

same angle of slope has been observed. Besides there have been studied dependence of measure capacity value C on the frequency of measurements.

One of the methods of the increase of junction sensitivity to the irradiation effect is the thickness rise of charge carrier range W_o. As it established that by doping with certain ionization potentials one can control W_o value. Besides for 99,99999% Se-based diodes at T increase above 80^0C W_o increase from 1 up to 15 micron. Thus for increase of Se p-n structure sensitivity as the indicator of the accelerated electrons by W increase there have been 2 opportunities a) control of W_o value by certain doping into Se; b) use of Se-based p-n structures of high frequency at high temperatures $\geq 80^0$C.

Another specific feature of se referring to the effect of penetrating radiation is that radiation promotes to the transition of amorphous Se into hexagonal one, i.e unlike many other substances there has been carried out transition from less ordered state into more ordered one under the effect of radiation. At points to the occurrence of clear lines of hexagonal selenium at considerably less crystallization time on electron-diffraction photographs and radiographs of preliminarily irradiated samples.

III. CONCLUSION

It is established that radiation sensitivity of reverse direction of selenium diodes is greater by several field according to the operation in valve regime. Collision ionization in p-n junction gives scope for creating more sensitive indicators for irradiation recording. According to our data for Se diodes in prebreakdown reversed voltages radiation – induced condition is by an order greater than in prebreakdown region. The ability of Se diodes to the momentary self-healing compares favorably with Si and Ge devices for the operation under the conditions of avalanche multiplication.

We should note that Se-based p-n junctions can be manufactured of various areas and geometries. This feature of Se-based devices are also different from Si and Ge devices for capture of wide beams of irradiation by one converter, determination of angle distribution of wide beams of irradiation and other measurements.

By thermo-, photo- and radiation excitation it is established that the main mechanism of prebreakdown rise of reverse current through p-n heterojunction is the collision ionization with deep traps of ionization rate $(7\cdot10^2\text{-}3\cdot10^3)\text{cm}^{-1}$.

As a result of comparative investigation of germanium, silicon and selenium diode structures for the last ones higher radiation stability and small radiation – induced conduction have been established. By the effect of high-energy penetrating radiation unlike other substances Se transition from less ordered state into more ordered own have been carried out. Steady radiation structural ruptures in Se are due to the molecular chain rupture not influencing markedly on device parameters on the base of Se hexagonal modification. Unsteadly radiation structural changes in the layer of space charge of Se p-n structures are attributed to long-duration carrier capture in “low” energy states.

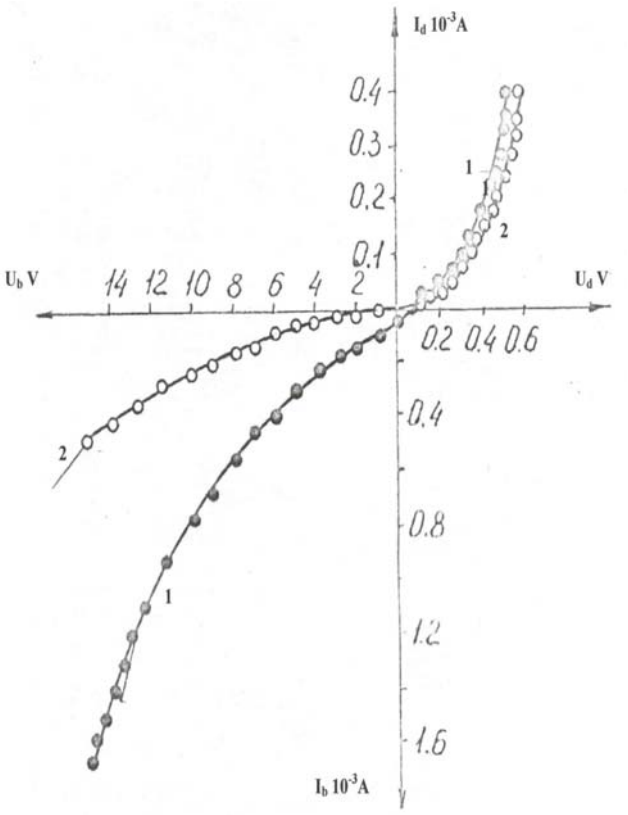

Fig. Static volt ampere characteristics of Se p-n junction before radiation and by radiation of accelerated electron beam with 1 MeV energy.
1-by radiation
2-before radiation

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