

Studying the Effect of X-ray Radiation on the Electrical Properties of Diodes 1N1405

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Abstract

The diode 1N1405 type silicon is subjected to different levels of energy and time irradiation. We have about three times; at every time we have measured the forward and reverse bias voltage of the diode to know what is the difference between the electrical properties of the same diode without irradiation of x-ray.

Keywords: X-ray, Electrical Properties, Semiconductors.

1. Introduction

X-ray is electromagnetic radiation ranging in wave from 10E-9 m to 10E-12 and can penetrate dense material, depending on the power of x-ray energy. The energy of x-ray related to the following parameters represented in the equation.

$$E=hc/\lambda \quad (1)$$

Where E is quantum energy of x-ray, h is plank's constant, c is speed of light and λ is wavelength of x-ray radiation.

X-ray is an extremely short wave with length high energy form of electromagnetic radiation which finds many applications in science and medicine. In chemistry we can use x-ray irradiation to study the degradation of organ compound [7]. Most applications however used x-ray of between 0.1A to 25 A [1, 2, 4]. The x-ray generator operates at high voltages, the production of x-ray arises by using high voltages to accelerate electrons emitted by an electron gun, which bombards metal target causing the generation of an x-ray spectrum.

The study of semiconductor materials began in the early nineteenth century [3]. Silicon and Germanium are the two most important semiconductors used in electronic devices. The crystal structure of these materials consists of a regular repetition in three dimensions of a unit cell having the form of a tetrahedron with an atom at each vertex [3, 5, and 6].

The p-n junction plays an important role in both modern electronic applications and semiconductor devices. It is used extensively in rectification, switching and the operations in electronic circuits. It is the basic building block for the bipolar transistors, thyristors and JFETS [3,5].

The interactions are between x-ray and crystal cause besides ionization, the production of different structural defect, in the crystal lattice. The three most important interactions of x-rays matter are: 1. Photoelectric effect; 2. Compton scattering and 3. Pair production.

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2. Experimental method

The current values at different bias voltages before and after x-ray irradiation diode 1N1405 type silicon as shown in table(1) and plotted as shown in fig (1- 5).

The first time irradiation			Second time irradiation			Third time irradiation		
Time irradiation	Volt	Energy x-ray	Time irradiation	Volt	Energy x-ray	Time irradiation	Volt	Energy x-ray
0.2	55	5.6	0.3	85	8.52	2.4	85	8.52

Table 1: Illustrate the current values at different bias voltages before and after x-ray irradiation diode type 1N1405. Time irradiation in (Sec.), Volt in (KV) and energy x-ray in (KeV).

The sample was irradiated using a 55 KV for period 0.2 sec and the current 20mA and in the second time 85 KV for period 0.3sec and current 160mA and the in third time for period 2.4 sec and current 100mA .

3. Result and Discussion

We find that the response diode 1N1405 silicon type before and after x-ray irradiation is significantly different as shown in fig. (1-5). We see in fig (2, 3, 4, 5) after x-ray irradiation the electrical properties were changed as show in fig.2 we saw two parts the first part of curve having potential barrier value are 0.5 voltage where the point was changed from 0.6 voltage before irradiation to 0.5 voltage after irradiation and the current increased to 17mA which means an increase of electron-hole in the depletion layer as result of breaking the equivalent band in 0.6 voltage.

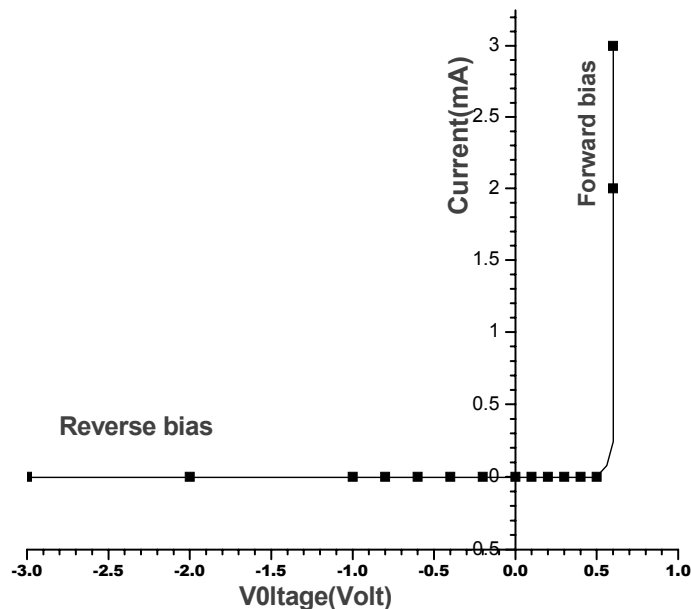


Fig. 1: Electrical properties of silicon diode type 1N1405 before irradiation.

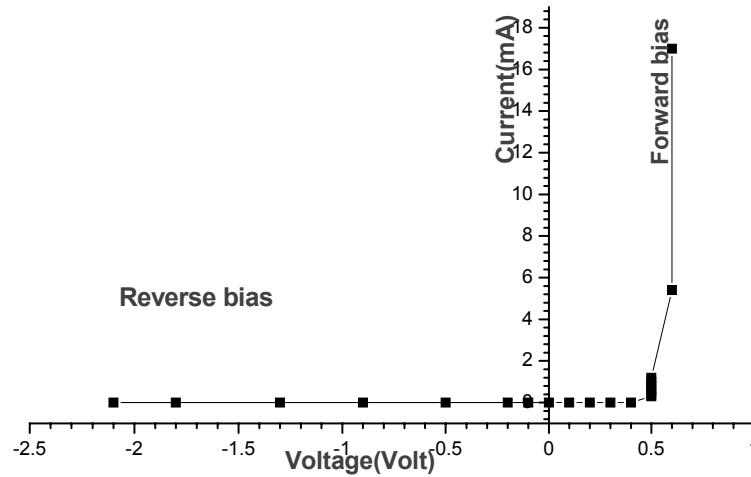


Fig. 2: Effect of X-ray irradiation ($t=0.2\text{Sec}$, $V=55\text{KV}$, 0.0056MeV) after one time irradiation on silicon diode type 1N1405.

In the second time of x-ray irradiation we saw three points potential barrier (0.4, 0.5, 0.6) voltage, at the point 0.4 volt the current is 0.1mA and at the second point 0.5 volt the current is 2.4 mA and at the third point the current increased to 5.4 mA as shown in fig.3; this means we can work at different points depending on the current we need.

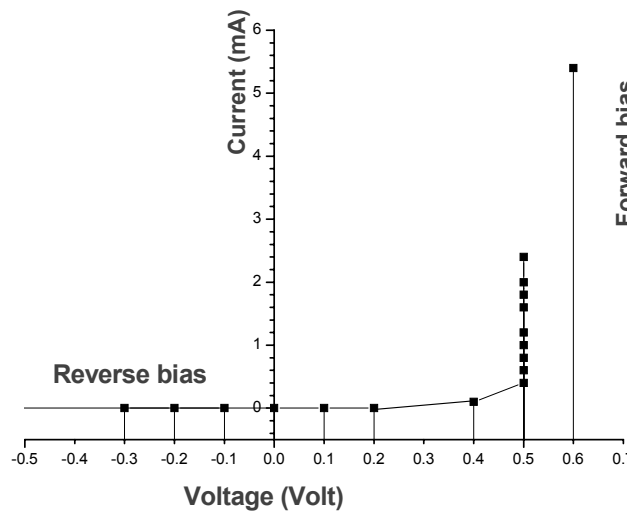


Fig. 3: Effect of X-ray radiation on Silicon diode type 1N1405 after second time irradiation ($t=0.3\text{ sec}$, $V=85\text{KV}$, $E=0.00852\text{ MeV}$).

In the third time of irradiation is as shown in fig. (4), the curve consists of three points, in levels. In some points, there is not difference from the second irradiation but the current at point 0.4 volt is 0.05 mA and at the second point 0.5 volt it is 1.4 mA and at the third point 0.6 volt it is 5 mA. As we know when x-ray incident on the crystal matter the interaction with crystal depends on the energy of x-ray radiation and the atomic number because the photon

when incident on matter has two probabilities: one is when the energy is not enough, the photon path cross through the matter without interaction, the second is when the energy is enough, like photo effect or Compton effect or pair production or Exton the atom, the photon interacts with the matter.

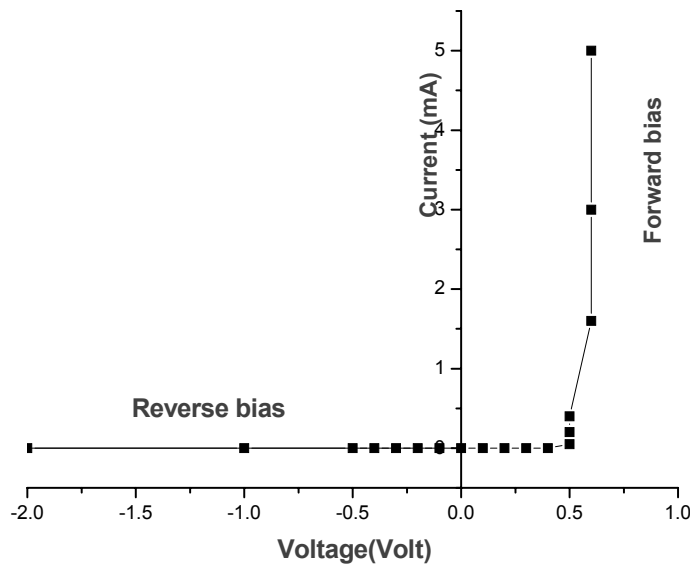


Fig. 4: Effect of X-ray radiation on Silicon diode type 1N1405 after third time irradiation ($t=2.4$ sec, $V=85$ KV, $E=0.00852$ Mev).

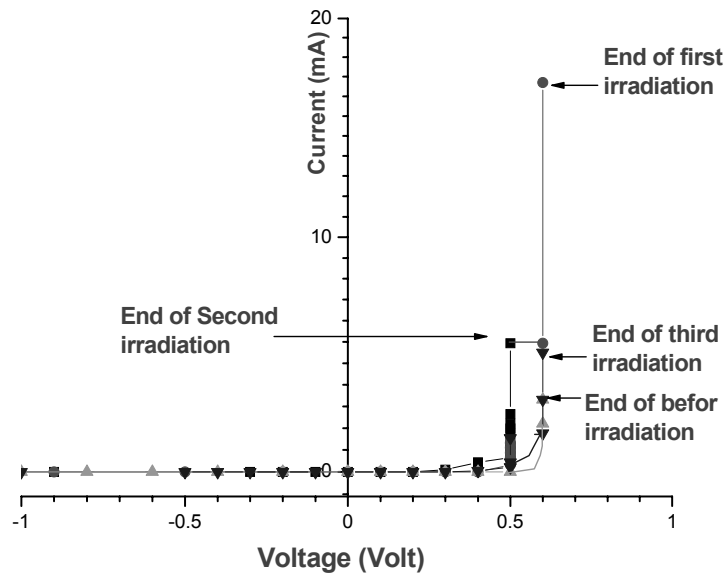


Fig. 5: Effect of X-ray irradiation on silicon diode type 1N1405.

Each one of the three operations produce electron-hole which affects the electrical properties of semiconductor .Electron-holes and Exton may be caught in many " traps" that exist in the crystal. Traps are formed in a variety of ways induced as result of irradiation, foreign atom, impurities such as interstitial atoms, dislocation, vacancies and imperfections may act as traps in the forbidden band gap. Trapping is of course undesirable because it means loss of part of the change carriers in the diode, thus causing reductions in its current or change in the properties of electrical diode as shows in fig (5).

Conclusion

The new properties of diode after x-ray irradiation give us much information about the effect of ionizing radiation on the electrical properties of the electronic devices which used in many experimental or in nuclear experimental and the most important after irradiation we saw increasing the current and we have different point potential barrier.

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