11th International Workshop on Computational Electronics
TU Wien, 25-27 May 2006

Study of the Light Intensity Threshold for Simulated PIN Photodiode under Proton Radiation

M.A. Cappelletti[1] and E.L. Peltzer y Blancá[1,2]
[1] Grupo de Estudio de Materiales y Dispositivos Electrónicos (GEMyDE), Depto. de Electrotecnia, Facultad de Ingeniería, Universidad Nacional de La Plata, 48 y 116, CC.91, La Plata (1900), Buenos Aires, Argentina
[2] Instituto de Física de Líquidos y Sistemas Biológicos (IFLYSIB) CONICET – UNLP – CIC, La Plata, Buenos Aires, Argentina
e-mail: mcappel7@yahoo.com.ar

INTRODUCTION

The knowledge of the space radiation environment is essential for predicting if a device will survive to the total radiation which will expect to encounter in a space mission.

The trapped proton fluxes are often the most important radiation consideration for devices especially designed to operate in spatial applications in low earth orbit (LEO), near 600 km altitude [1]. This illustrate why proton testing is important.

The PIN (p-intrinsic-n) photodiodes are every time more used in spatial applications. The PIN photodiodes are semiconductor devices that answer to high energy particles and photons generating a flow of current proportional to the incident power.

The effects of the radiation studied were the atomic displacement damages.

PHYSICAL MODEL

The modelling and simulation of the PIN photodiodes were done solving the Poisson and continuity equations self consistently [2, 3]. This results were compared with experimental values.

RESULTS AND DISCUSSION

In this work we present results of nine differently constructed PIN photodiodes exposed to spatial radiation. In Fig. 1 we show a simplified PIN photodiode. Table 1 gives the characteristic lengths of the nine simulated PIN photodiodes.

All the simulations considered the effects of 10 MeV proton radiation on the PIN photodiodes. The fluencies used were of 1×10^{13}, 5×10^{13}, 1×10^{14}, 2.5×10^{14} p^+/cm^2 and zero fluence (not irradiated photodiode). We included in our simulation the effects produced by the light illumination on the photodiodes. The intensities used were ranged from 0 to 100 mW/cm^2. The wavelength of the incident light was 900 nm (in the infrared band).

A comparison among the nine simulated PIN photodiodes irradiated with 2.5×10^{14} p^+/cm^2 is shown in Fig. 2, where a lineal relation between the total reverse current and the light intensity can be seen for each PIN photodiode. We can also see in Fig. 2 that the slopes rise when the length of the intrinsic region increase, therefore, the efficiency in the detection of photons and protons is maximized. Similar results were obtained for the others fluencies simulated.

From these results we have obtained one expression that relates the total reverse current and the incident radiation.

The simulation results in Fig. 3 show the current increment when a PIN photodiode (PIN_4) is exposed to several proton fluencies regarding to the not irradiated photodiode. For each set of curves of each PIN photodiode, the straight line of the total reverse currents in function of light intensities have a cross point called threshold.

The light intensity threshold (LIT) is not constant, it is variable for each PIN photodiode. The variation of the LIT with the length of the type p, intrinsic and type n regions is shown in Fig. 4. We have deducted an expression that reproduce the behaviour of the LIT. We can see that the LIT decreases when the length of the type p and type n regions are increased.

CONCLUSION

With the codes generated we are able to reproduce very precisely the behaviour of the PIN photodiodes studied under proton radiation.

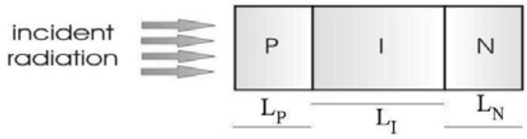

Fig. 1. Simplified scheme of a PIN photodiode, where L_P, L_I and L_N are the length of the type p, intrinsic and type n regions respectively.

	L_P [μm]	L_I [μm]	L_N [μm]
PIN_1	0.9	28.2	0.9
PIN_2	1.35	27.3	1.35
PIN_3	1.8	26.4	1.8
PIN_4	2.25	25.5	2.25
PIN_5	2.7	24.6	2.7
PIN_6	3.6	22.8	3.6
PIN_7	4.5	21.0	4.5
PIN_8	4.95	20.1	4.95
PIN_9	5.4	19.2	5.4

Table 1. Characteristic lengths of the nine simulated PIN photodiodes. All the simulations were considered with $L_P + L_I + L_N = 30\ \mu m$ and $L_P = L_N$.

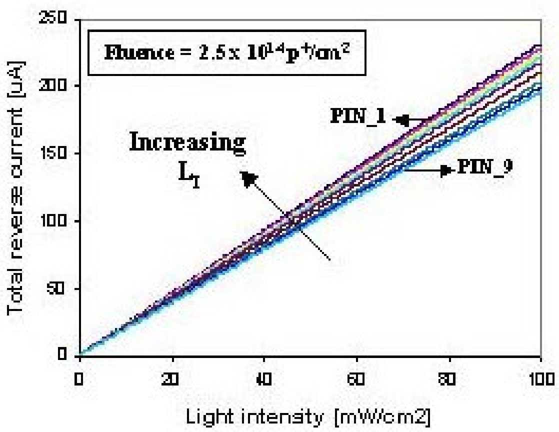

Fig. 2. Total reverse current in function of light intensity at 10V for the irradiated nine simulated PIN photodiodes at one proton fluence.

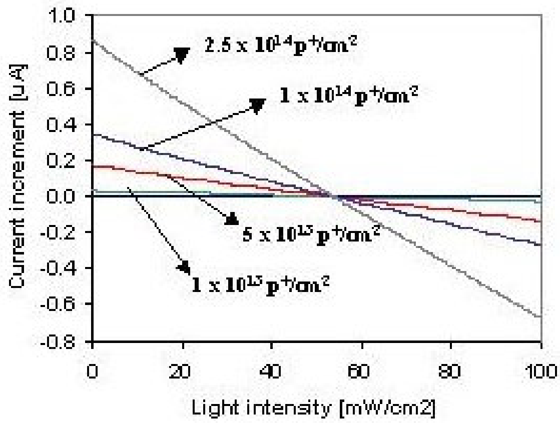

Fig. 3. Light intensity versus current increment for a irradiated PIN photodiode (PIN_4) at several proton fluencies.

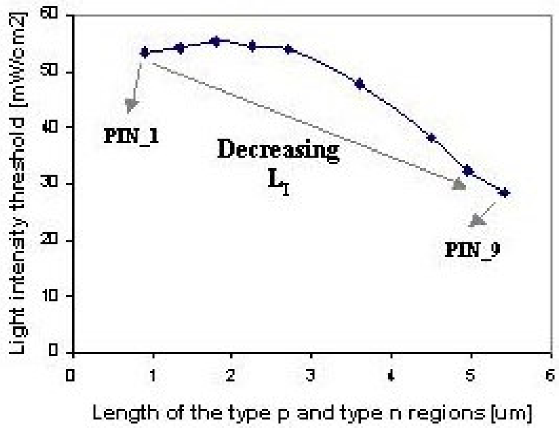

Fig. 4. Variation of the light intensity threshold (LIT) with the length of the type p and type n regions.

REFERENCES

[1] M. Xapsos, S. Huston, J. Barth and E. Stassinopoulos, *Probabilistic Model for Low-Altitude Trapped-Proton Fluxes*, IEEE Transactions on Nuclear Science, NS-**49** (6), 2776 (2002).

[2] D.G. Yagüez, D. Villarraza, M.A. Cappelletti and E.L. Peltzer y Blancá, *Study of semiconductor devices exposed to spatial radiation,* WSEAS Transactions on Systems, Issue 3, Vol **3**, 1228 (2004).

[3] D.G. Yagüez, D. Villarraza, M.A. Cappelletti and E.L. Peltzer y Blancá, *Simulation of PIN Photodiodes Exposed to Spatial Radiation*, WSEAS (World Scientific and Engineering Academy and Society) accepted publication (2004).