INTERNATIONAL JOURNAL OF RESEARCH IN COMMERCE, IT, ENGINEERING AND SOCIAL SCIENCES (IJRCIESS) ISSN: 2349-7793
Vol. 4 No. 12 (2010): December
Double-Blind Peer Reviewed Refereed Open Access International Journal

INFLUENCE OF ELECTRON IRRADIATION ON ELECTRICAL AND OPTICAL CHARACTERISTICS OF (LIGHT EMITTING DIODES) LEDS.

B. JAYASHREE,
Department of Physics,
APS College of Arts & Science
Bengalore

ABSTRACT

The presence of light emitting diodes (LEDs) is being felt increasingly in day-to-day life. One of the major attractions of LEDs is their long lifetime. Hence a systematic study would be useful to understand level of performance, degradation due to various external factors such as temperature, high energy particle irradiation etc. The purpose of this study is to test the radiation hardness, a measure of LEDs ability to operate near maximum efficiency after being irradiated with electrons. A systematic study has been made to understand the effect of electron irradiation on LEDs with and without encapsulation (LED chips) of primary colours. The samples were irradiated by 8 MeV electrons with different radiation dosages from 500 Gy to 160 KGy. Electrical and optical properties of the samples were carried out before and after irradiation. From the current –voltage measurement the operating voltage of the red LEDs after irradiation at 30KGy was reduced from 2.2V to 2.15V at 20mA and for blue, green LEDs and blue, green LED chip selectron irradiation does not have any significant effect on operating voltage. The dynamic resistance of red LEDs decreases as the radiation increases.This work indicates that the dynamic resistance of all other sample's remains practically unchanged by irradiation, indicating that the concentration of electrically active atoms are much larger than that of defects (vacancies) created by electron irradiation. There wasno significant change in dominant wavelength of the emission spectra of LEDs and LED chips except red LEDs, suggesting GaN LEDs seems to be radiation hard under the laboratory conditions.

Keywords: LEDs, I-V characteristic, emission spectra, irradiation, KGy.

1. INTRODUCTION

Gallium indium nitride/gallium aluminium arsenide/gallium nitride (GaInN/GaAlAs/GaN)- based materials have attracted considerable interest in relation to their potential use in optoelectronic devices, such as light emitting diodes (LEDs) and laser diodes (LDs) [1-5]. These LEDs are a promising irradiation source for plant growth in space. The improved semiconductor technology has yielded LED devices fabricated with GaAlAs/GaN chips, which have a high efficiency for converting electrical energy to photo synthetically active radiation [6]. By regulating the defects formation, one-can optimize electrical characteristics of the device to the required level [7]. The electrical properties of the device such as forward voltage drop, reverse recovery charge before and after irradiation is extremely helpful in estimating the lifetime of devices working in radiation environment [8].

The study on high-energy electron irradiation induced effects in LEDs and LED chips were carried out with an objective to investigate modifications in optical and electrical characteristics.

2. EXPERIMENTAL

The chips of blue and green colour LEDs made out p & n type layers of InGaN grown over sapphire substrate prepared by M/s LED rep which is a division of M/s AXT, USA and LEDs of all three basic colours of GaN/AlGaInP prepared by M/s CREE Corporation were used in this study. The blue LED structure consists of SiC substrate on which GaN layer is grown epitaxially. The LEDS are encapsulated with Hysol os4000 epoxy for characterization. The p and n junction area of LEDs is 240 x 240μm^2.

The LED chips (without encapsulation) of area 375 x 325 μm^2 were selected for comparison. The Die bonding (epoxy bonding) and wire bonding of the chips were done at M/s Bharat Electronics Ltd, Bangalore. First the I-V measurement of LEDs before irradiation were done using Keithly source and measurement unit (SMU236)which is interfaced with a computer. The source voltage is 1µV to 100V and source current is 100fA to 100mA and sensitivity of the instrument is 10fA and 10µV.

Emission spectra at room temperature were performed on all the prepared samples using the setup consisting of a SMU, a monochromatic grating, Ge/Si photo detector and few mirrors. The LEDs should be powered up using a SMU and all the spectra were recorded when the current was kept at 70mA constantly. The emission wavelength width (FWHM) and dominant wavelength of LEDs before irradiation were determined.

Then the samples were subjected to electron irradiation at room temperature with beam energy 8MeV with a pulse current 50mA (max.), at different dosages starting from 500Gy to160KGy. Electron irradiation was done using a variable energy microtronat Microtron center, Mangalore University, Mangalore. The I-V and emission spectra measurements were performed after each dosage.

3. RESULTS AND DISCUSSION

3.1. Current-Voltage Characteristics

The forward I-V plot for blue, green and red LEDs and for green and blue LED chips before irradiation are shown in the Fig. 1.

The linear and semi log I-V plots of blue LEDs before and after irradiation of electron at different dosages (0.5, 5,10, 20, 40, 50, 55, 110 and 160 KGy) are as shown in the Fig. 2(a) and (b) respectively.

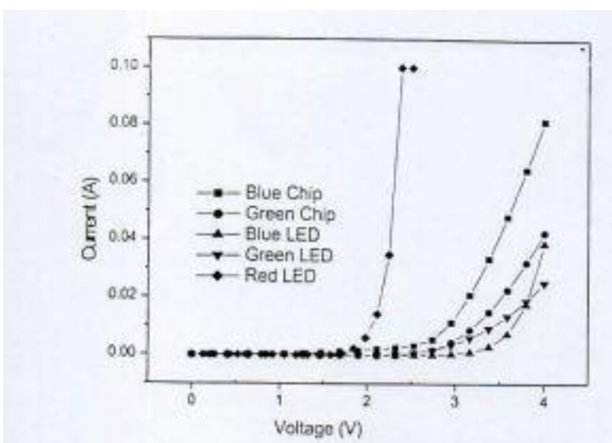


Fig.1. I-V characteristics of LEDs and LED chips before electron irradiation.

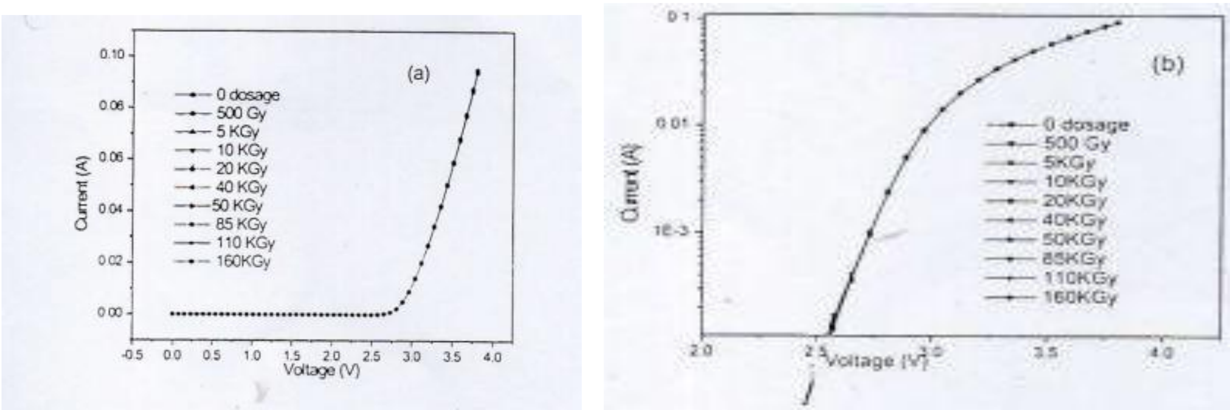
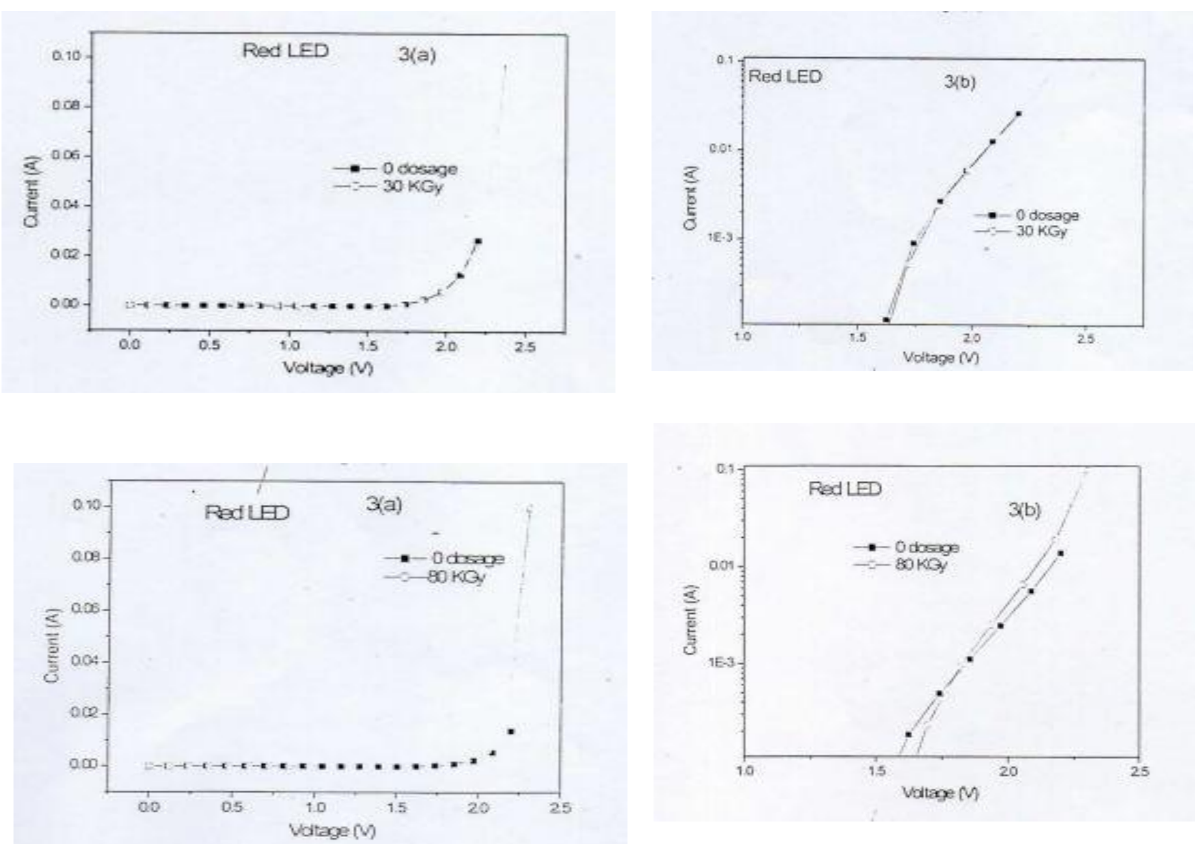


Fig.2.(a) I-V forward curves of blue LEDs, (b) Semi-logarithmic I-V plots of blue LEDs before and after electron irradiation at different radiation dosages.

Fig. 3(a) shows I-V curves for red LEDs before and after electron irradiation at different dosages starting from 30 KGy to 130 KGy (as there is no change in the forward current up to 30KGy. The I-V curves are not shown here) and Fig.3(b) shows, the corresponding semi-log plots.



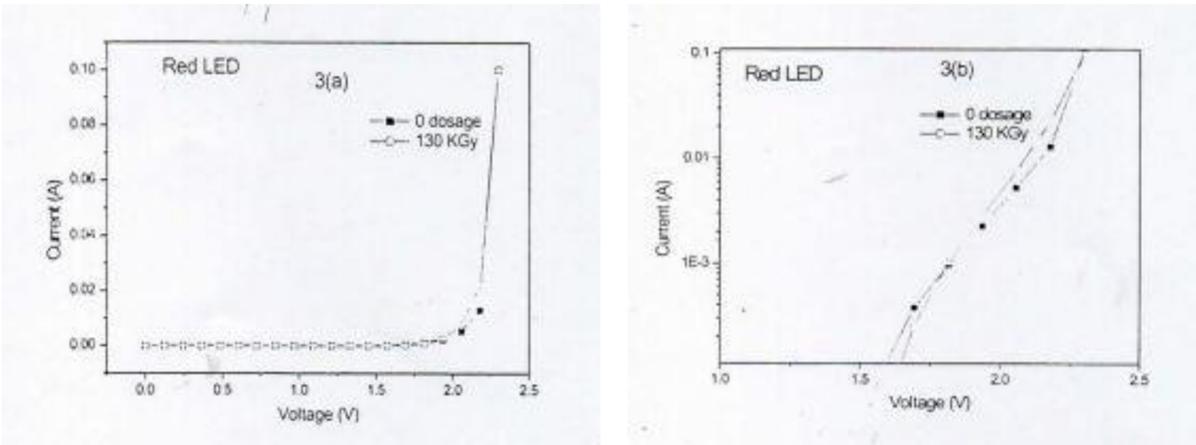


Fig.3.(a) I-V forward curves of red LEDs, (b) Semi-logarithmic I-V plots of Red LEDs before and after electron irradiation at different radiation dosages.

The I-V Characteristics for blue and green LED chips are shown in Fig.4(a) and (b).

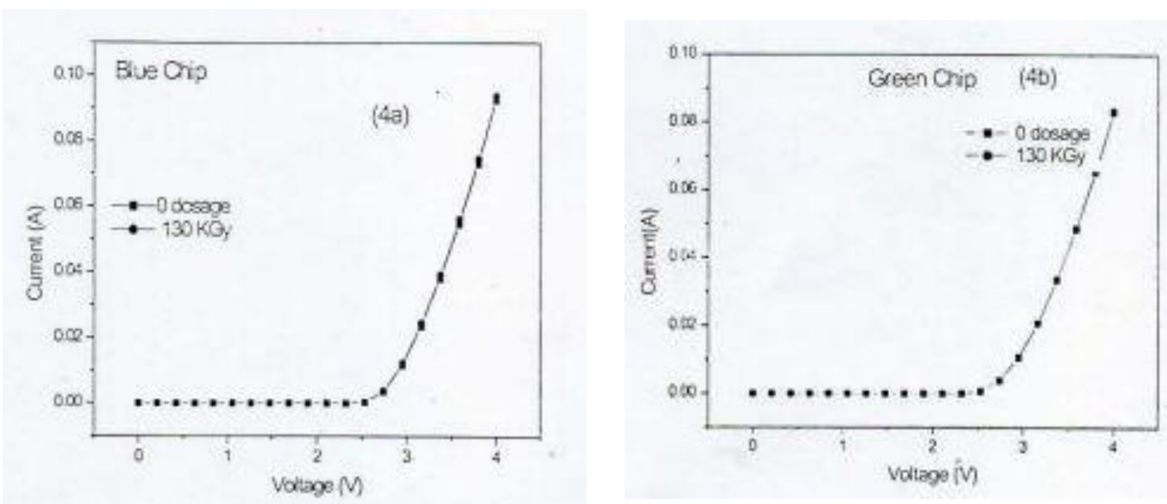


Fig.4.Comparision of forward bias LED chips I vs V curves before and after electron irradiation (a) Blue LED chip, (b) Green LED chip.

In the I-V characteristics plots, as the positive voltage is increased the current almost increases linearly till it reaches turn on voltage. The increase of current is no longer linear but increases exponentially. From this region it can be observed that due to the steepness of the I-V curve, very large current can be generated with the increase of modest voltage. LED forward voltage varies with colour and current as seen in Fig.1

All LEDs and LED chips before and after irradiation exhibit same forward I-V behavior. The dynamic resistance of all the samples beforeand after electron irradiation are calculated using the relation R = dV/dI. The semilog plots are plotted to calculate ideality factor and saturation current density of LEDs. The slopes of these plots are equal to q/nkT, where n is an ideality factor and Y-intercept is equal to saturation current density (I).

The ideality factor (n) and saturation current density (I_s) determined from fig.2(b), 3(b) yields almost same values for each samples before and after irradiation. The forward voltages of the unirradiated and irradiated blue, green LEDs and its chips were almost same (3.16V for blue LEDs) at a driving current of 2OmA.Where as for red LEDs before electron irradiation the forward voltage is 2.2V and after irradiation it is 2.15V at 20KGy radiation dosage. The observation suggests that there is no degradation in the efficiency of the LEDs inspite of discolouration in the encapsulations.

3.2. Spectral Response/Emission Spectra

The Spectral response is one of the main optical techniques used to characterize the emission of LEDs. The emitting light will have certain wavelength which corresponds to colour. However it is obvious that the emitted light from LED will not be monochromatic in nature i.e. there will be certain spreading in the spectral response distribution. So for our LED applications, it is important to have the knowledge of spreading over central wavelength of emission before and after electron irradiation.

Fig. (6) to (8) shows the emission spectra of LEDs before and after electron irradiation at 30, 80 and 130KGy and Figure (9) to (1 1) shows that of LED chips at same radiation dosages.

The emission wavelength width (FWHM) and dominant wavelengths of LEDs before and after irradiation were determined. There were only minor changes in the emission spectra above the dosage at 30KGy.The full width half maximum (FWHM) of the emission spectra of red LED after irradiation at 30KGy at room temperature was 48 nm. suggesting inhomogeneous broadening of the emission. This broadening indicated that the particles (electrons) occupy a range of sites, with slightly different energy levels in the GaN/InGaN host.

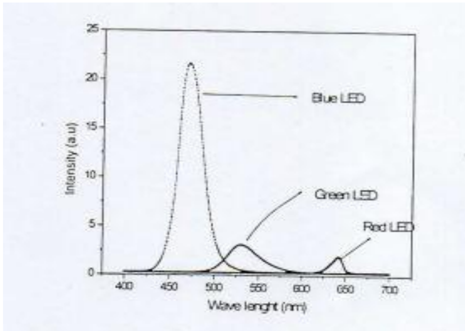


Fig. 5. Emission spectra of LEDs before electron irradiation.

Fig. 5. Emission spectra of LEDs before electron irradiation.

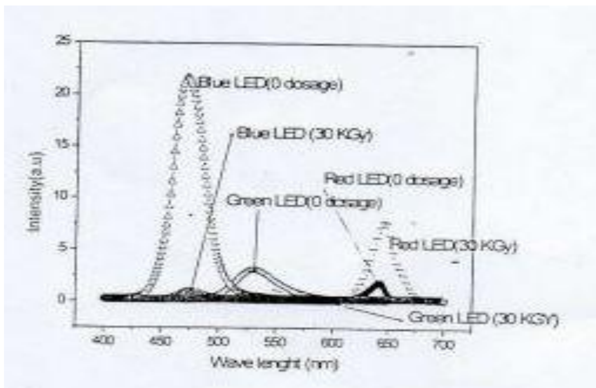


Fig. 6. Emission spectra of LEDs before and after electron irradiation at 30 KGy.

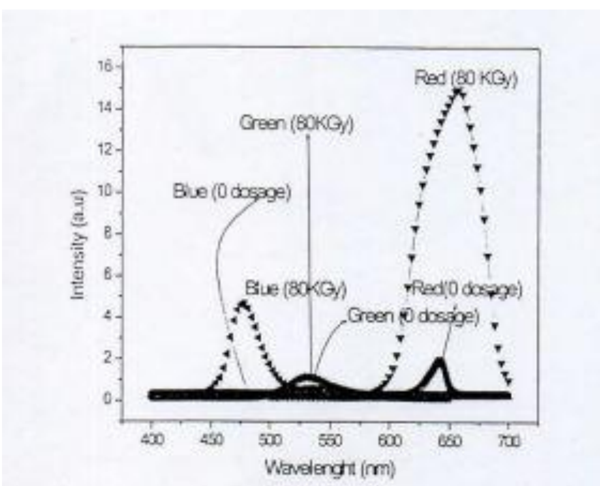


Fig. 7. Emission spectra of LEDs before and after electron irradiation at 80 KGy.

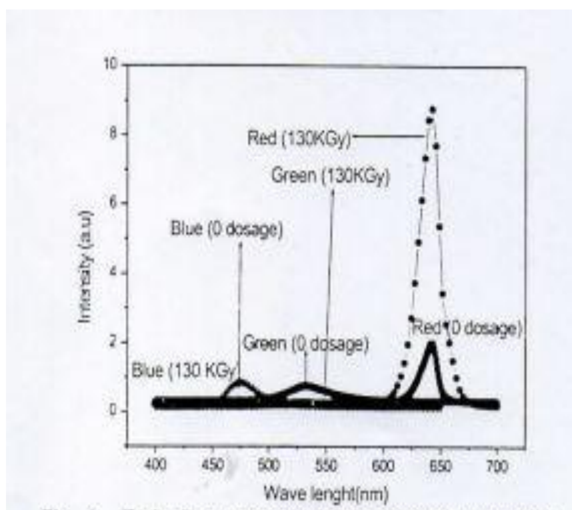


Fig. 8. Emission spectra of LEDs before and after electron irradiation at 130 KGy.

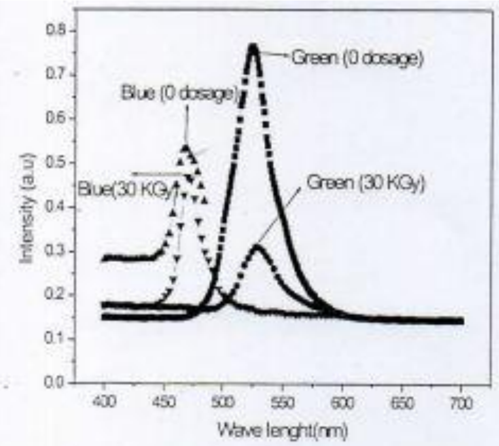


Fig. 9. Emission spectra of LEDs chips before and after electron irradiation at 30 KGy.

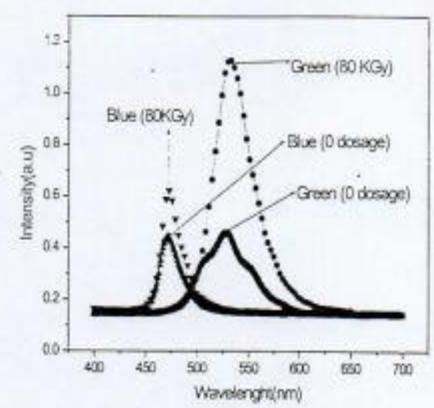


Fig. 10. Emission spectra of LEDs chips before and after electron irradiation at 80 KGy.

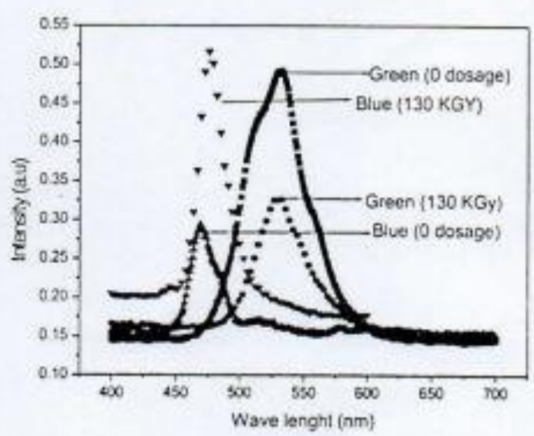


Fig. 11. Emission spectra of LEDs chips before and after irradiation at 130 KGy.

Table 1:Table showing dominant wave length ,FWHM for LEDS and LED chips before and after irradiation of electron at dosages (i)30 KGy (ii)80 KGy & (iii)130 KGy.

BEFORE IRRATION			**AFTER IRRADIATION**	
LEDS	DOMINANT WAVE LENGTH (nm)	FWHM (nm)	DOMINANT WAVE LENGTH (nm)	FWHM (nm)
RED	(i) 641 (ii) 643 (iii)641	14.86 14.86 14.86	645 657.5 642.4	22.85 48.18 19.69
GREEN	(i) 529 (ii) 532 (iii)531	37.51 39.27 39.83	530 532.5 530	36.60 37.88 39.59
BLUE	(i) 470 (ii) 470 (iii)470	26.74 31.81 23.16	472 477 477	23.97 27.1 27.13
BLUE CHIP	(i) 467 (ii) 471 (iii) 469	26.04 22.77 22.07	470 472.7 475.7	20.57 20.77 22.67
GREEN CHIP	(i) 523 (ii) 527 (iii)531	35.01 47.94 48.76	527 530 524	28.24 41.51 41.87

CONCLUSION

The LEDs made out of GaN and LED chips have not exhibited significant degradation in efficiency or other diode parameters up to electron dosage of 160KGy in case of blue LEDs (GaN) but the degradation occurs for the LEDs made out of GaInN at dosage of 3OKGy itself. From the current-voltage measurement the operating voltage of the red LEDs after irradiation at 30KGy is reduced from 2.2V to 2.15V at 20mA. The dynamic resistance of red LEDs decreases as the radiation dosage increases. This is due to displacement of indium atom. which is present in red LED, and the energy of light emitted mainly depends on the medium concentration of the material. For blue, green LEDs and blue, green LED chips electron irradiation does not have any significant effect on operating voltage This work indicates that the dynamic resistance of all other samples remains practically unchanged by irradiation there by indicating that the concentration of electrically active atoms are much larger than that of defects (vacancies) created by electron irradiation. There was no significant change in dominant wavelength of the emission spectra of LEDs and LED chips except red LEDs, suggesting GaN LEDs seem to be radiation hard under the laboratory conditions.

ACKNOWLEDGEMENTS

One of the authors would like to thank the management, A.P.S Educational Trust and UGC for deputation to Bangalore University under faculty Improvement Programme (FIP) to carry out research.

REFERENCES

1) Hung-Wen Huang, J T Chu, C C Kao, T H Hseuh, T C Lu, H C Kuo, S Cwang and C C Yu, Enhanced light output of an InGaN/GaN light emitting diode with a nano-roughened p-GaN surface Nanotechnology 16 (2005) 1844-1848.
2) Nakamura S, Senoh M, Nagahama S, Iwasa N. Yamada T, Matsushita T, Sugimoto Y and Kiyoku H (1997) Room-temperature continuous-wave operation of InGaN multi-quantum-well-structure laser diodes with a long lifetime Appl. Phys. Lett. 70, 868-70
3) Nakamura S, Senoh M, Iwasa N and Nagahama S (1995) High-brightness InGaN blue,green and yellow light-emmitting diodes with quantum well structures Japan.J.Appl.Phys. 34 L797-9.
4) Mukai T and Nakamura S (1999) Ultraviolet InGaN and GaN single- quantum- well-structure light emitting diodes grown on epitaxially laterally overgrown GaN substrates Japan.J.Appl.Phys.38 5735-9.
5) Nakamura S,Mukai T and Senoh M (1994) Candela-class high-brightness InGaN/AlGaNdouble-heterostructure blue-light-emitting diodes Appl.Phys.Lett.64 (1687-9).
6) Barta D J, Tibbitts T W, Bula R J, Morrow R C Evaluation of light emitting diode characteristics for a space-based plant irradiation source. Adv. Space Res.1992; 12 (5): 141-9.

7) A.I onascut-Nedelcescu, C.Carlone, A.Houdayer, H.J.Von Bardeleben, J.L Cantin and S.Raymond "radiation Hardness of Gallium Nitrade, IEEE Tras.Nuc.Sci.,Vol.49,No.6,Dec 2002.
8) Shyam M.khanna,Diego Estan,Alain Houdayer,Hui C.Liu and Richard Dudek "Proton Radiation Damage at Low Temperature in GaAs and GAN Light-Emitting Diodes". IEEE Tras. Nuc. Sci., Vol. 51, No. 6, Dec 2004.