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8 MeV electron irradiation effects on light emitting diodes

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ABSTRACT

The studies on the effect of electron irradiation on commercially available light emitting diodes (LEDs) have been studied in this work. The electron irradiation on LEDs made of GaAs, AlGaAs, DH AS AlGaAs, GaP, AlInGaP, GaN, and InGaN are undertaken. All the devices are irradiated under unbiased conditions. The electron irradiation effects on the current voltage, light output versus forward bias current and bias voltage characteristics of the LEDs are studied. A thermal annealing study also carried out on the irradiated LEDs having metal package.

Keywords: LEDs, electron irradiation, GaAs, GaN, InGaN, Current voltage characteristics.

INTRODUCTION

The study of radiation effects in semiconductor devices has been an important area of research to understand the fundamental physics of semiconductors as well as to the applications of semiconductor materials and devices [1]. The radiation induced defects lead to degradation of semiconductor device parameters. The development of radiation-resistant devices is an active area of research for the application of radiation resistant devices in the radiation harsh environments like space mission, high energy particle colliders, and military equipments [2]. The optoelectronic devices are important components for space and military applications. The radiation induced defects influence the absorption or generation of light in optoelectronic devices and hence the degradation of the device characteristics [3-6]. In this work, the effect of 8 MeV electron irradiation on the electrical parameters of commercial LEDs has been carried out.

MATERIALS AND METHODS

The commercial LEDs having TO-46 metal can package as well as plastic package were used in this study. The metal can package LEDs were Honeywell make infrared GaAs LED SE3455 with peak emission wavelength 935 nm and AlGaAs LED SE3470 with peak emission wavelength 880 nm. The plastic package LEDs were: (1) Hewlett Packard make DH AS AlGaAs HLMP-C115 red LED with peak wavelength 645 nm, (2) Hewlett Packard make GaP HMLP-3950 green LED, (3) Hewlett Packard make InGaAlP HLMP-EG 30- MQ000 red LED with peak wavelength 626 nm, (4) Kingbright make GaN on SiC LED L-53 MBE blue with peak emission wavelength 430 nm, and (5) Kingbright make InGaN on SiC LED L-7113VGC-E LED green with peak emission wavelength 518 nm. The irradiation is carried out at Microtron centre, Mangalore University with 8 MeV electrons. The irradiated LEDs are characterized by forward current-voltage, light output versus forward bias current and bias voltage measurements. The post annealing effects on the characteristics of the irradiated metal can package GaAs and AlGaAs LEDs are also studied. The current voltage measurements are carried out using Keithley 236 source measure setup. A phototransistor (Fairchild make L14G) is used for the measurement of LED light output as the photocurrent output of the phototransistor. The post irradiation annealing of the irradiated metal can package GaAs and AlGaAs LEDs are carried out for 30 minutes each at 100, 150, 200, 250 and 300^{o}C.

RESULTS AND DISCUSSION

Fig. 1and 2 shows the forward current - voltage characteristics of the electron irradiated metal case GaAs and AlGaAs LEDs, respectively. In the generation-recombination region of the current-voltage characteristics, an increase in forward current is observed in both the LEDs as the irradiation dose is increased. This indicates an increase in generation-recombination related current due to irradiation induced defects in the depletion region of the LED. Also, in both GaAs and AlGaAs LEDs, an irradiation induced decrease in the forward diode current is observed in the high-level injection/series resistance region of the diode with increase in irradiation dose. This is due to the defect creation in the neutral region of the diode. Fig. 3 and 4 shows the current – voltage characteristics of GaAs and AlGaAs LEDs after successive annealing for 30 minutes at temperatures 100, 150, 200, 250, and 300^{o} C, respectively. A slight recovery in the current - voltage characteristics is observed after post irradiation annealing. That is, decrease in the generation-recombination region current and increase in high-level injection/series resistance region current is observed. This indicates the partial annealing of the irradiation induced defects. A similar behavior in the light output of the LEDs is observed with electron irradiation and post irradiation annealing as shown in Fig. 5 to 8. Fig. 5 to 8 shows the light output (detector current) versus forward current as well as forward voltage for the LEDs before irradiation, after 30 kGy electron irradiation, and 300^{o}C post irradiation annealing for 30 minutes.

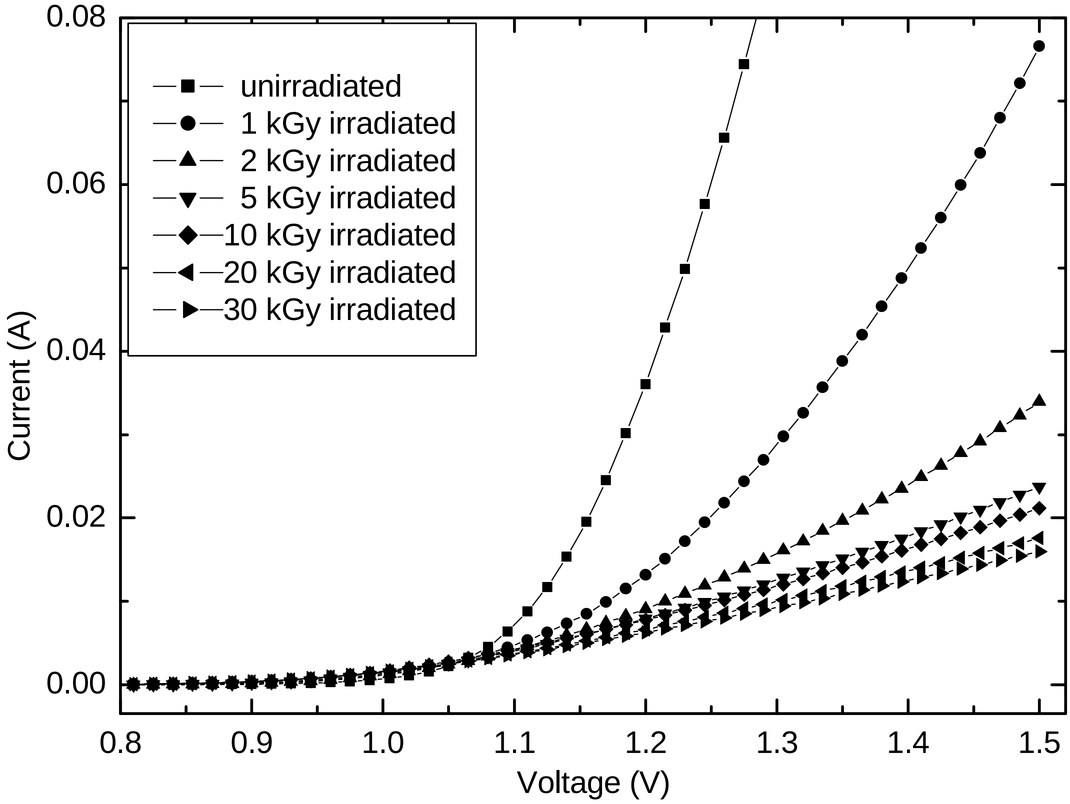

Fig. 1 Current versus voltage of GaAs LED at various accumulative irradiation doses

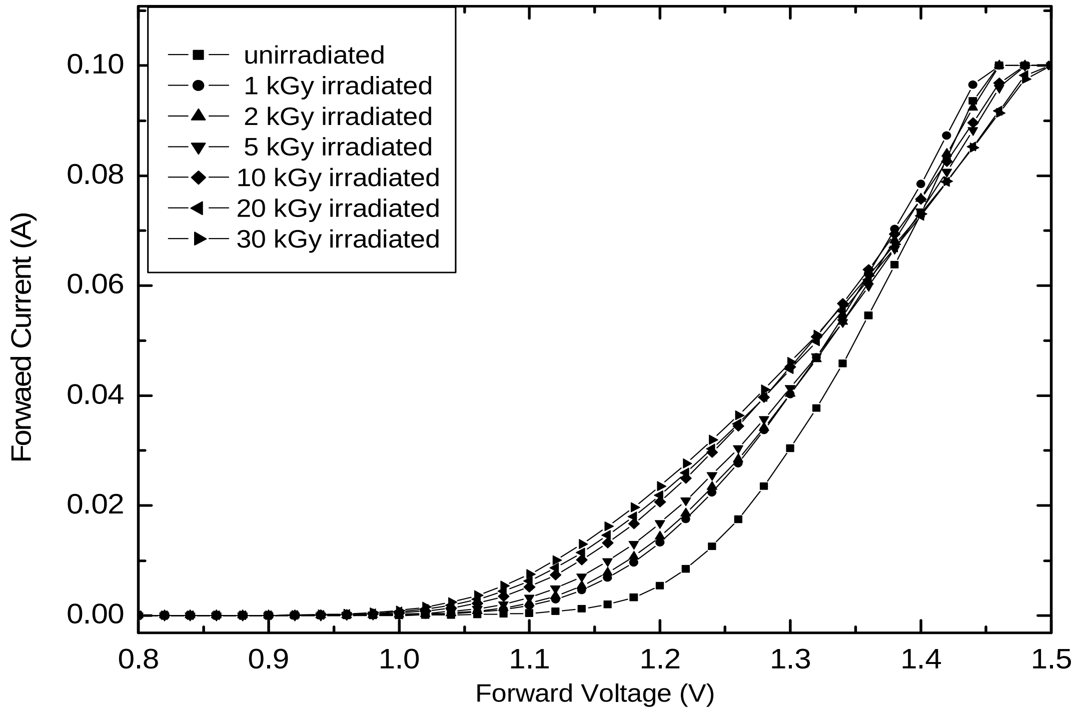

Fig. 2 Current versus voltage of AlGaAs LED at various accumulative irradiation doses

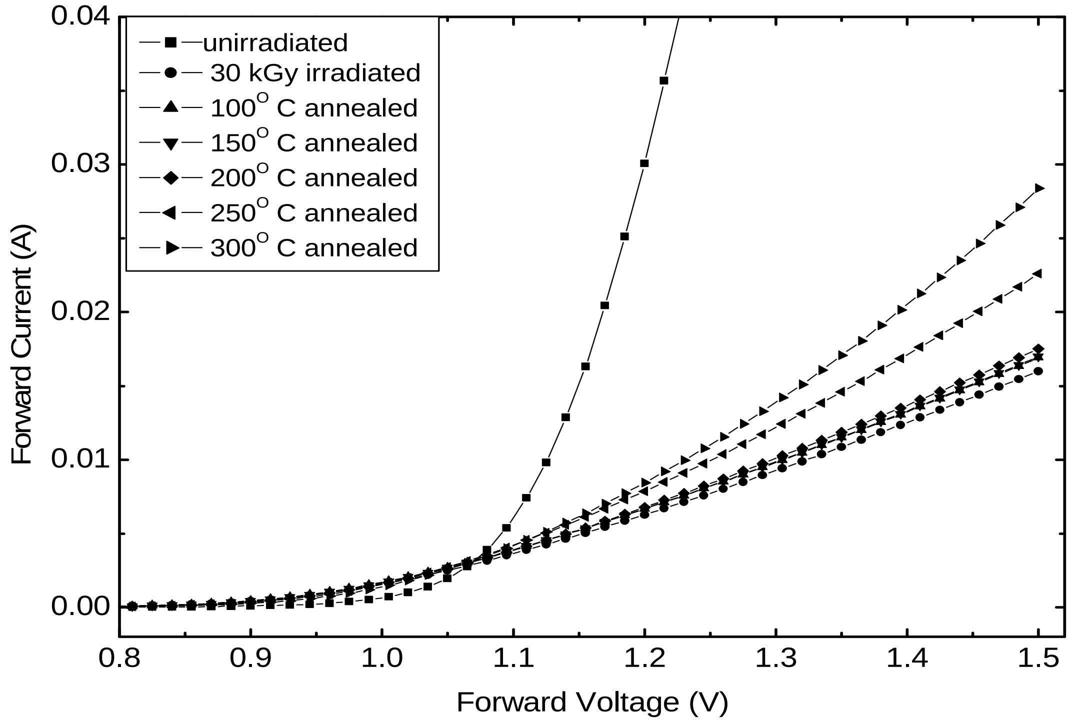

Fig. 3 Forward current versus voltage of 30 kGy irradiated GaAs LED with annealing

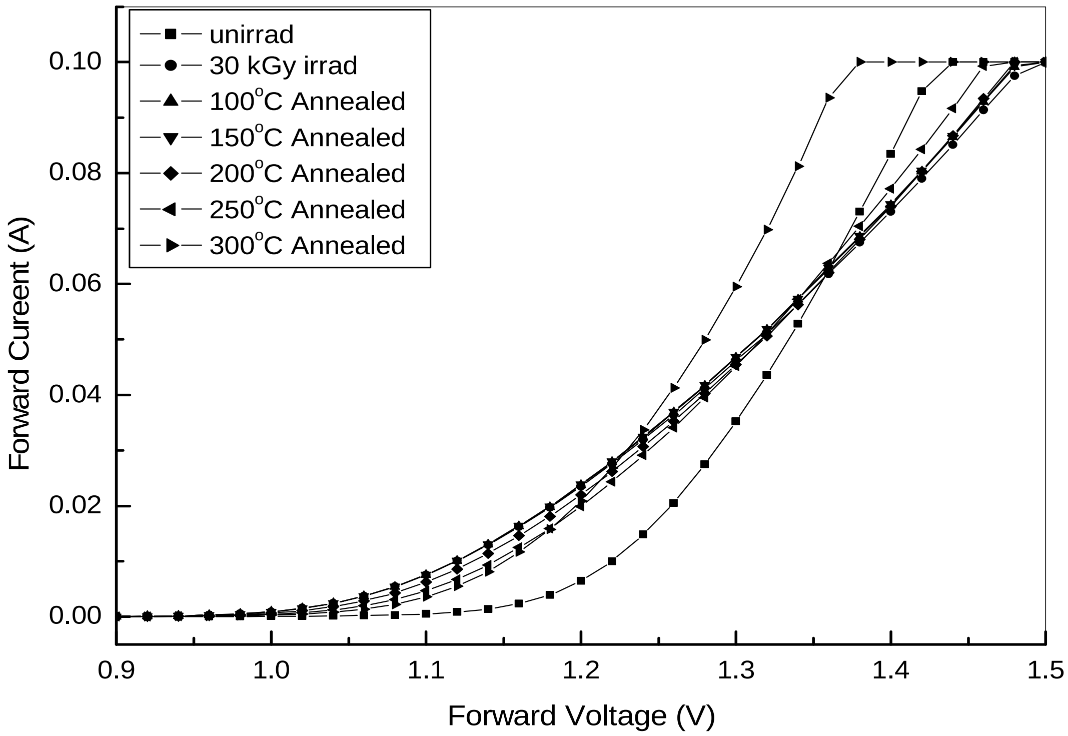

Fig. 4 Current versus voltage of 30 kGy irradiated AlGaAs LED with annealing

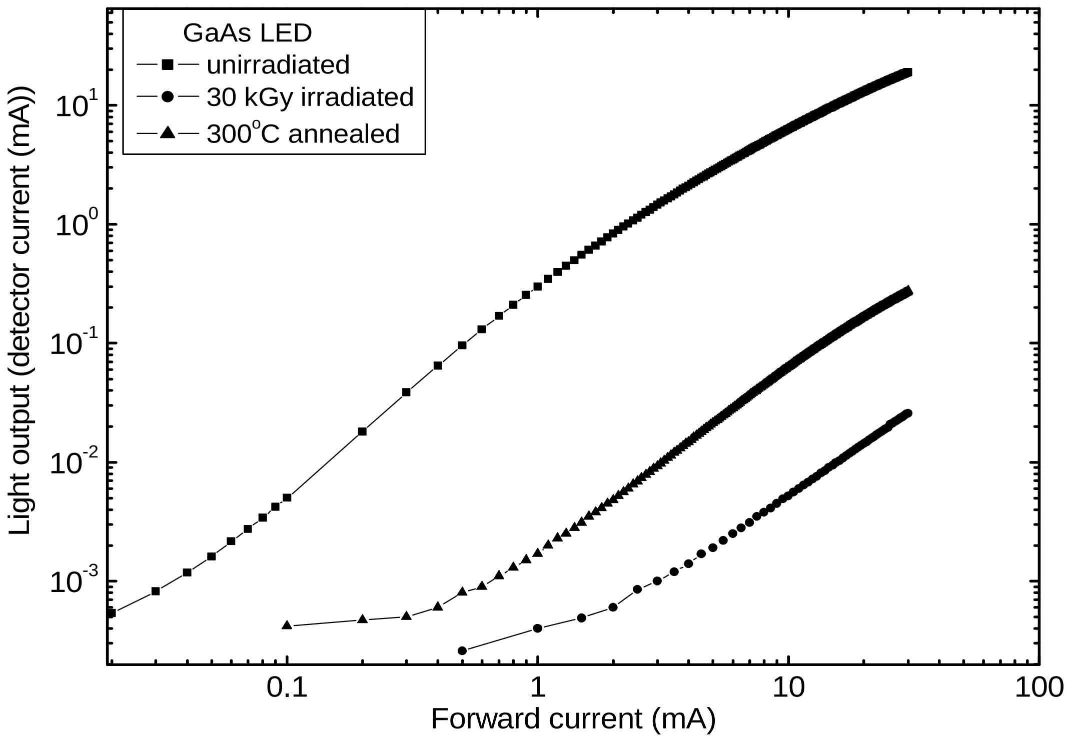

Fig. 5 GaAs LED light output versus forward current

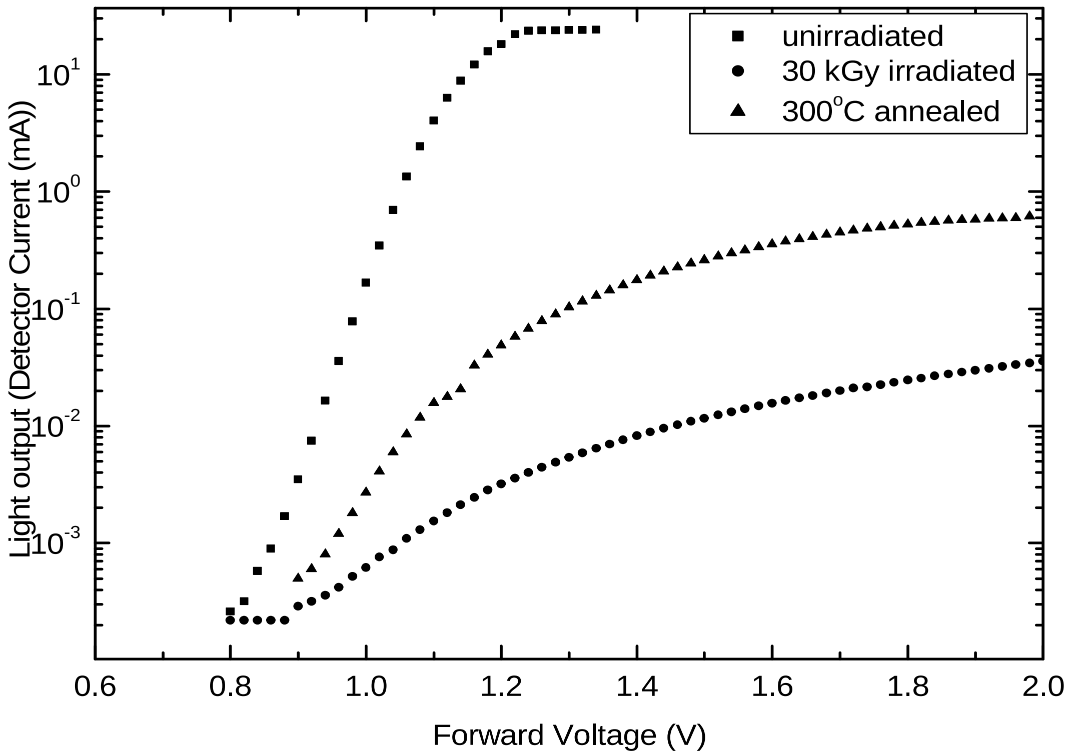

Fig. 6 GaAs LED light output versus voltage

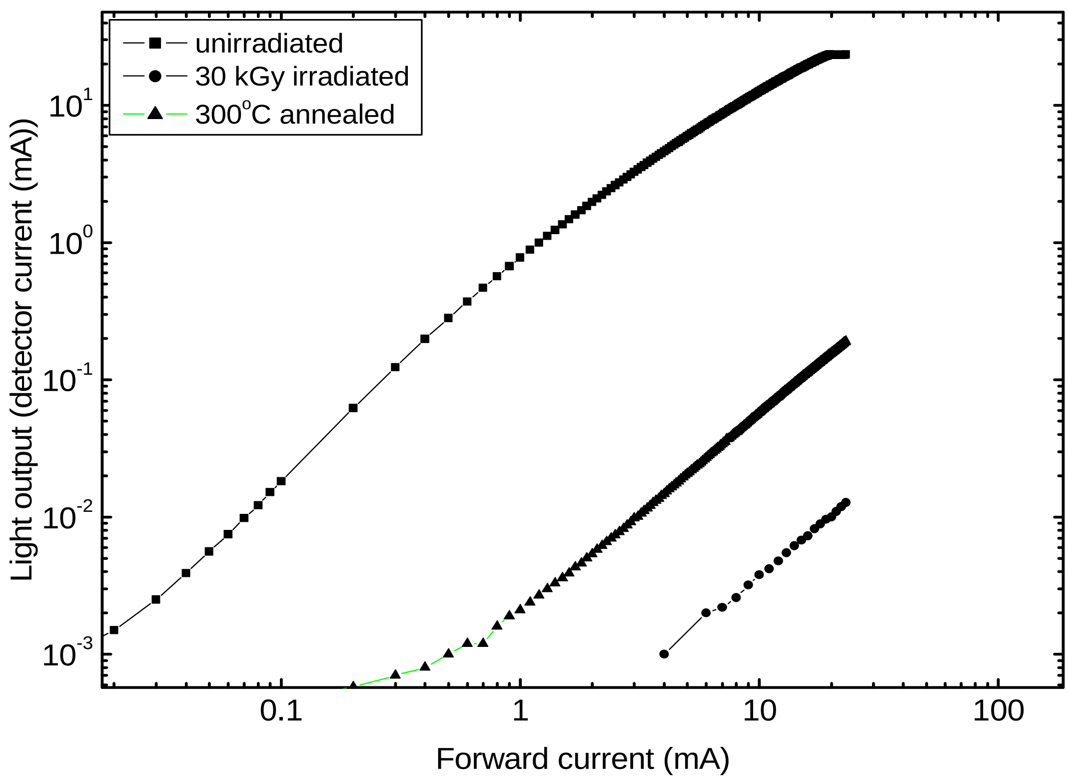

Fig. 7 AlGaAs LED light output versus forward current

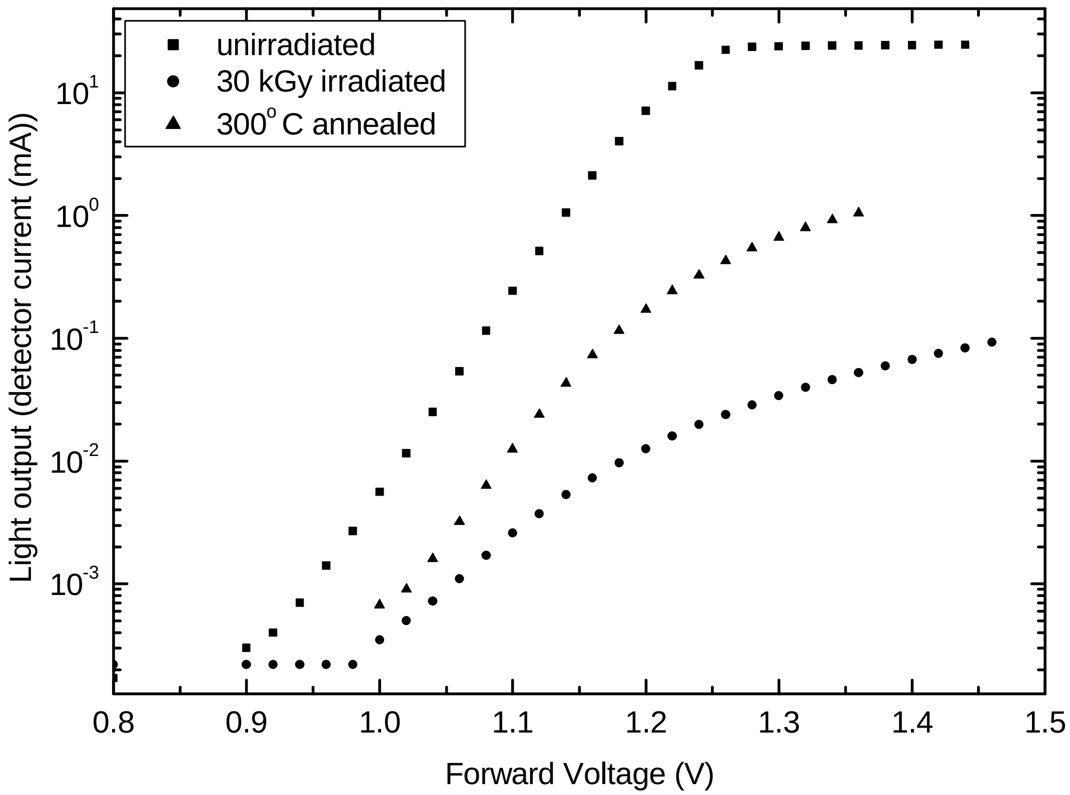

Fig. 8 AlGaAs LED light output versus forward voltage

The plastic package DH AS AlGaAs, GaP, InGaAlP, GaN, and InGaN LEDs were irradiated at room temperature with accumulative dose of 1 kGy to 50 kGy. The effect of irradiation on the current-voltage characteristics of DH AS AlGaAs, GaP, and InGaAlP LEDs are very similar to that observed in case of GaAs and AlGaAs LEDs; shown in Fig. 9 - Fig. 11. However, as shown in Fig. 12 and 13, no change in the current-voltage characteristics of the GaN and InGaN LEDs are observed with irradiation. It is found that the electron irradiation leads to degradation in the plastic case LEDs. Therefore, we could not compare the light output (detector current) versus forward current or forward voltage for these LEDs before and after electron irradiation.

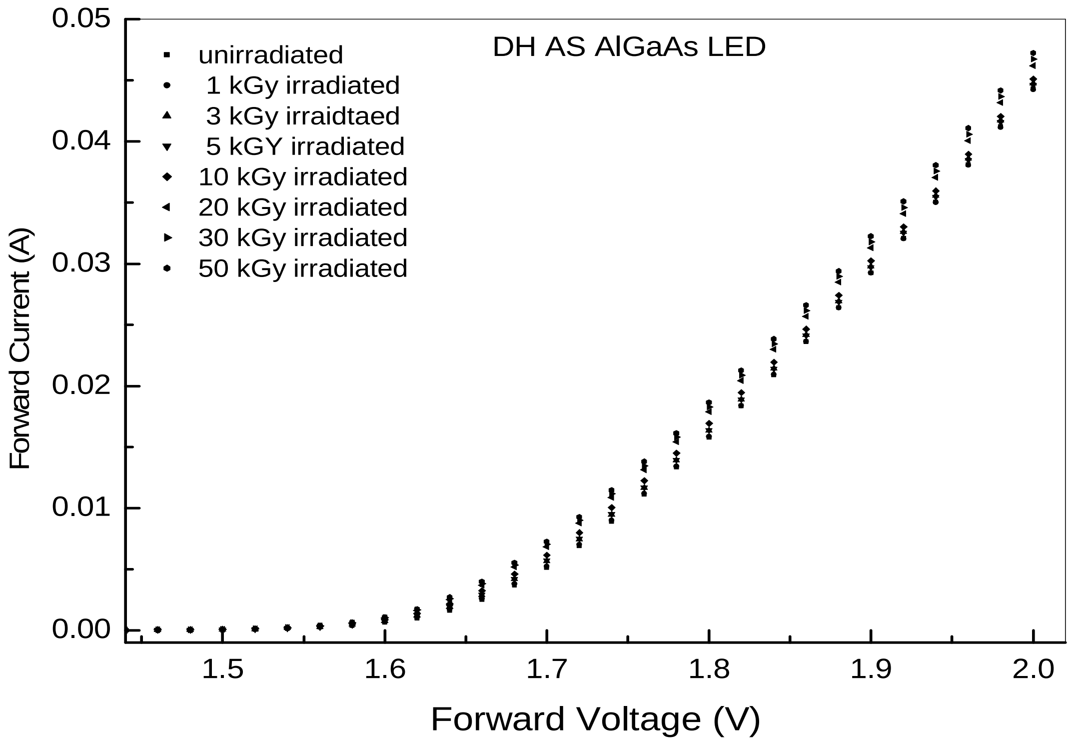

Fig. 9 Current versus voltage of DH AS AlGaAs LED at various accumulative irradiation

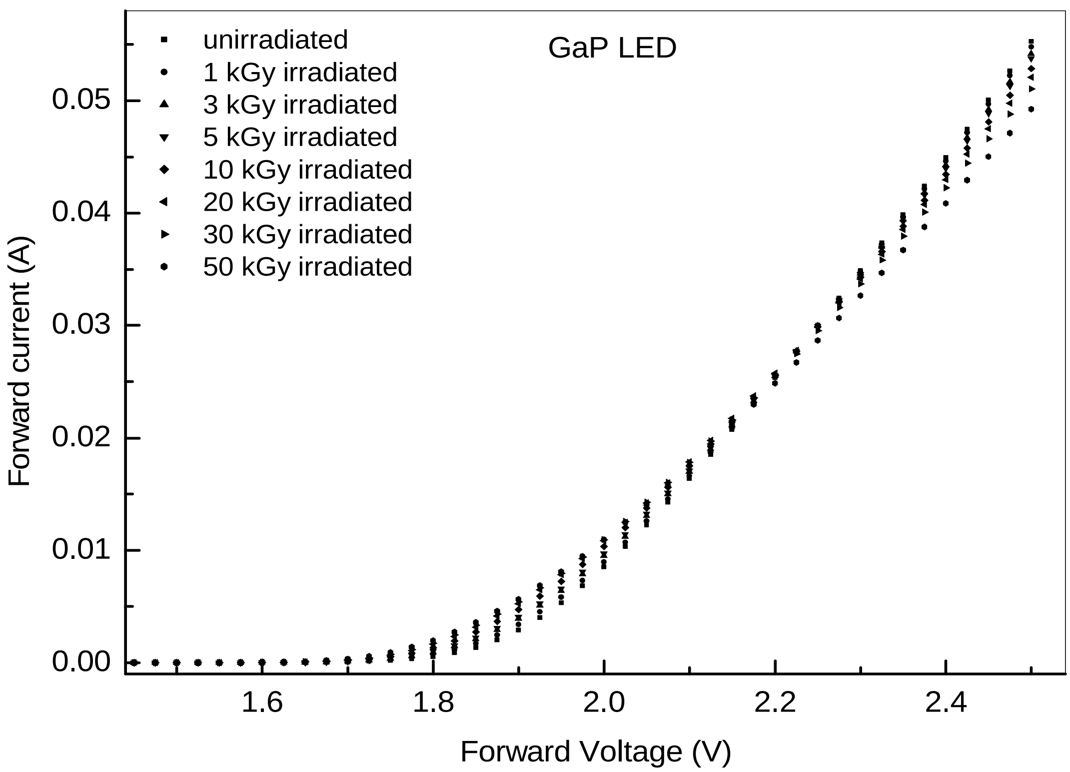

Fig. 10 Current versus voltage of GaP LED at various accumulative irradiation doses

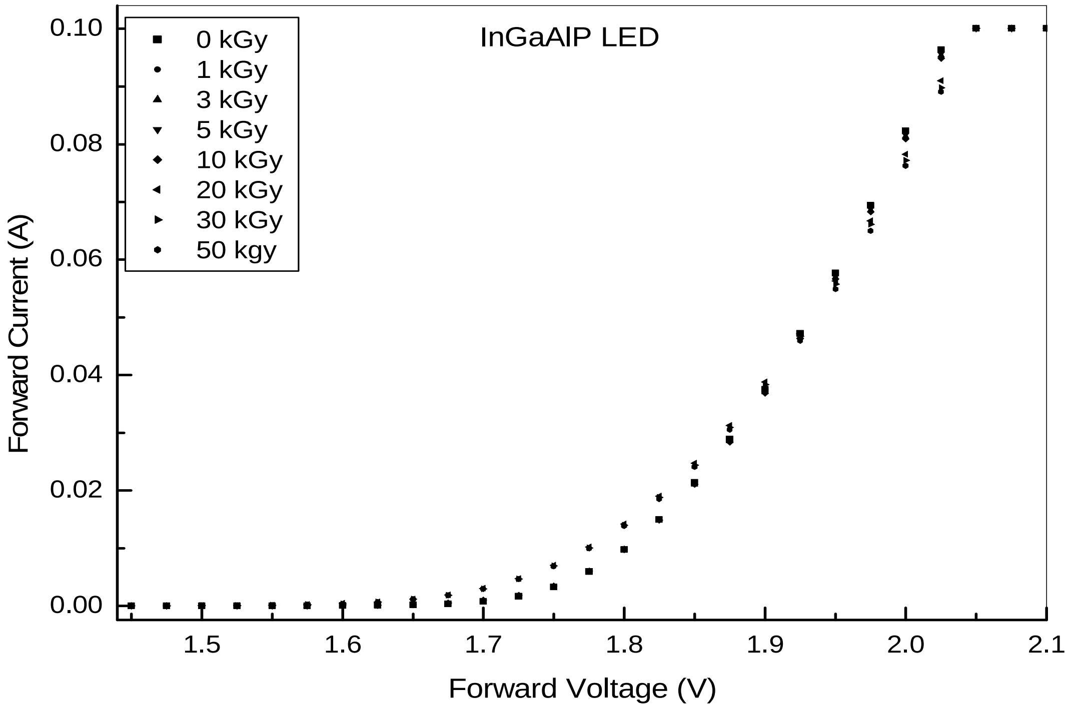

Fig. 11 Current versus voltage of InGaAlP LED at various accumulative irradiation doses

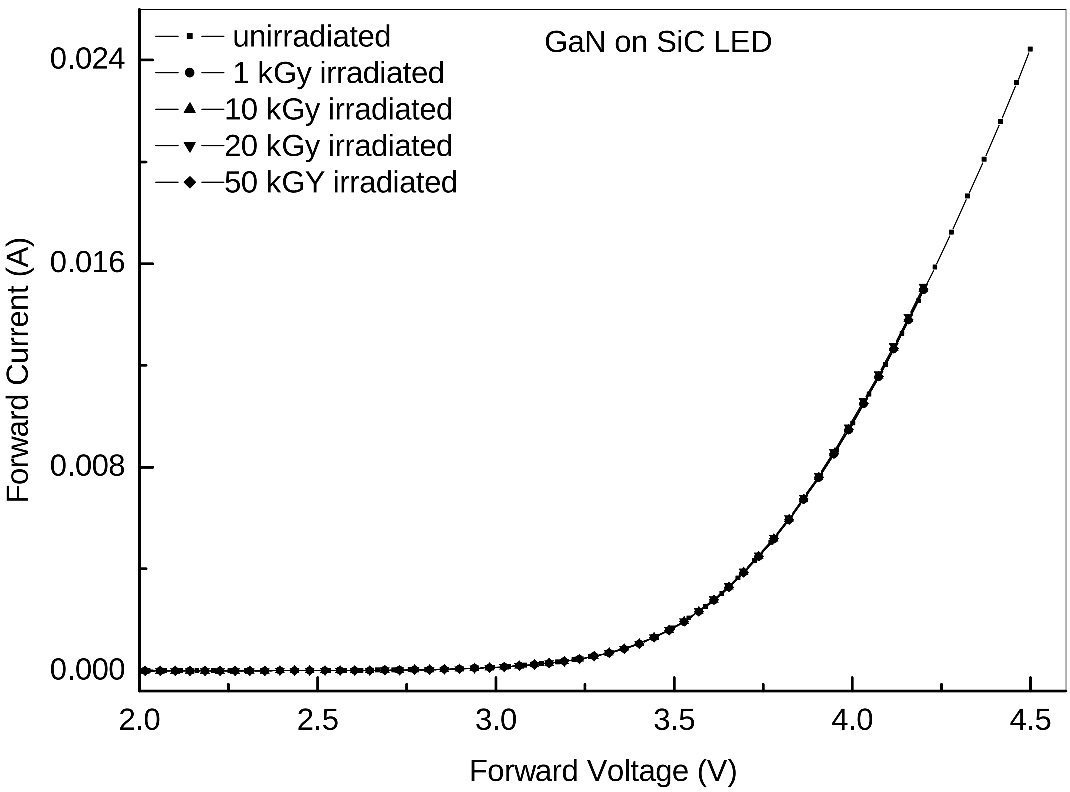

Fig. 12 Current versus voltage of GaN LED at various accumulative irradiation doses

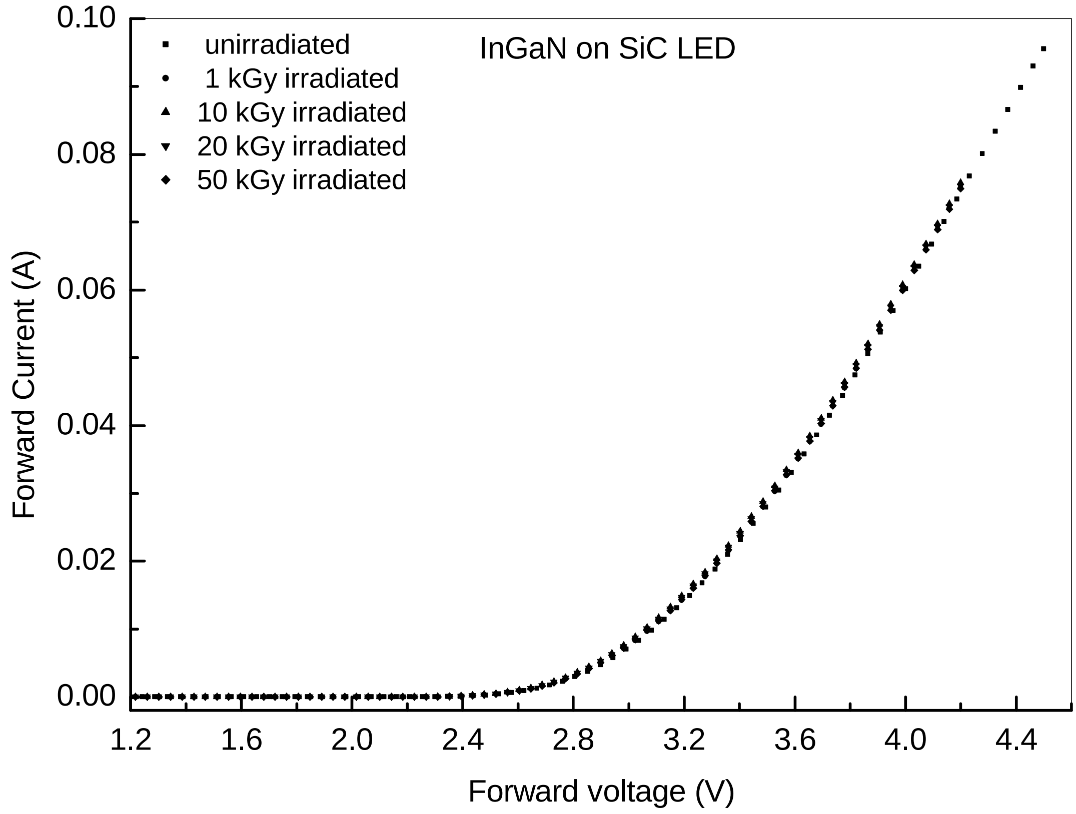

Fig. 13 Current versus voltage of InGaN LED at various accumulative irradiation doses

CONCLUSION

The study of the effect of 8 MeV electron irradiation is carried out on commercial LEDs. In the generation-recombination region of the current-voltage characteristics of GaAs, AlGaAs, GaP, and InGaAlP LEDs , an increase in forward current is observed as the irradiation dose is increased. This indicates an increase in generation-recombination related current due to irradiation induced defects in the depletion region of the LEDs. Also, an irradiation induced decrease in the forward diode current is observed in the high-level injection/series resistance region of the diode with increase in irradiation dose due to the defect creation in the neutral region of the diode. A decrease in the light output also observed in all the LEDs after irradiation, indicating the decrease in radiative recombination and increase in nonradiative recombination due to radiation induced defects. The post irradiation thermal annealing is carried out on metal package GaAs and AlGaAs. Annealing leads to partial recovery in the device characteristics. However, in the case of GaN and InGaN no noticeable change in the current- voltage characteristics is observed even after electron irradiation dose of 50 kGy.

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REFERENCES

[1] A. Khan, M. Yamaguchi, T. Aburaya, S. Matsuda, *Semicond. Sci. Technol.*, **2000**, 15, 403.
[2] C.C. Bueno, A.A.S. Correˆa, F. Camargo, J.A.C. Gonc-alves, P.F.P. R. Mendes, *Nuclear Instruments and Methods in Physics Research A*, **2004**, 533, 435- 441.
[3] B. H. Rose, C. E. Barnes, *J. Appl. Physics*, **1982**, 53, 1772-1780.
[4] H. Ohyama, K. Takakura, K. Hayama, S. Kuboyama, Y. Deguchi, S. Matasuda, E. Somoen, C. Claeys, *Appl. Phys. Lett.*, **2003**, 82, 296-298.

[5] S. M. Khanna, D. Estan, L. S. Erhardt, A. Houdayer, C. Carlone, A. Ionascut-Nedelcescu, R. S. Messenger, J. Robert. Walters, G. P. Summers, H. Jeffrey. Warner, I. Jun, *IEEE Trans. Nucl. Sci*., **2004**, 51, NO. 5, 2729-2735.
[6] H. Ohyama, K. Takakura, H. Shitogiden, M. Motoki, K. Matsuo,S. Kuboyama, E. Simoen, C. Claeys, *Physica*, **2007**, B 401–402, 33–36