γ Radiation Induced Transmission Characteristics Studies in Plastic Optical Fibers

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Abstract. Optical fibers are extensively used in many applications. Effect of nuclear radiations on transmission characteristics of optical fibers being studied in order to use optical fibers in radiation dosimeters. Optical fibers show nuclear radiation induced loss. This loss depends upon many factors viz, composition of fiber, operating wavelength, energy of nuclear radiation, does rate, etc. Presently optical fibers made of polymethyl metha acrylate (PMMA) are extensively used in local area networking due to low cost, easy cleavability and splicing. PMMA optical fibers are reused even after they are extensively studied for radiation dosimetry. In the present work, the attenuation of plastic optical fiber is studied under beta radiation emitted by Tl^{204} isotope of energy strength 0.764MeV and gamma radiation emitted by Na^{22} isotope of energy 1.274MeV respectively using visible and IR wavelengths emitted by He-Ne laser and near IR laser diode respectively. The results are compared for the amount of attenuation induced. It is observed that the plastic optical fibers show nuclear radiation induced loss. Plastic optical fibers are showing higher attenuation at visible wavelength region than at IR region. But observed induced loss is very small. Alike silica core fibers, plastic core fibers show negligible radiation induced attenuation in IR region than in visible region.

Keywords: Optical fiber, Attenuation, Radiation.

INTRODUCTION

Optical fibers are extensively used in communication and much research work is going on to bring up optical fiber sensors in variety of fields. When silica optical fibers are exposed to nuclear radiation, the attenuation in the fibers increases due to the radiation induced ionization and formation of colour centers. These effects can strongly reduce the performance of the fibers during the data transmission [1,2]. The nature of this loss depends on number of factors- core and cladding material composition, temperature, optical intensity, operating wavelength, dose rate, total dose, energy level of radiation etc. Lot of research work is being conducted to study the radiation effects on optical fibers for the purposes of: (1) using fibers as the information transmission system under high radiation environments where the radiation resistance of the fibers is a key issue and (2) exploring the possibility of using this effect to fabricate fiber optic radiation sensors under various radiation environments, such as in nuclear waste tanks, nuclear reactors and radiation therapy. In present days plastic optical fibers (POF) are extensively used in local area networking. POF are inexpensive, easy to cleave or couple to other fibers and suitable for high bandwidth signal transmission over short distances. Unlike glass fibers, POF can be easily cut and bent to fit in hard to reach places and larger core allows slightly damaged fibers. Hence, they have been extensively used in very short distance applications such as – industrial buses for controlling process equipment in rugged manufacturing environment, consumer related applications such as home theater and home networking applications.

In the present work, the attenuation of plastic optical fiber is studied under beta radiation emitted by Tl^{204} isotope of energy strength 0.764MeV and gamma radiation emitted by Na^{22} isotope of energy 1.274MeV respectively using visible and near IR wavelengths emitted by He-Ne laser and near IR laser diode respectively.

EXPERIMENT

We used plastic optical fiber (Industrial Fiber Optics Inc). It is bare fiber with PMMA core of diameter 480μm on which 20μm fluorinated polymer layer acts as cladding. As per the company specification, numerical aperture is 0.5 and attenuation 0.2dB/m at 650μm. n_{core} =1.492, n_{cladd} =1.402.

The attenuation in the fiber was determined using differential method. We used experimental fiber in two lengths - L_1 and L_2. Experimental setup is shown in Fig.1. Laser light is launched into fiber using coupler. Output at the other end is measured using optical power meter (Newport Model No. 1815-C and detector 818-SL series).

We determined the attenuation of the PMMA fiber using He-Ne laser (632.8nm, maximum output-5mW) and near infrared laser diode (Newport Model No-FK-18281) of optical output 3mW at 780nm.

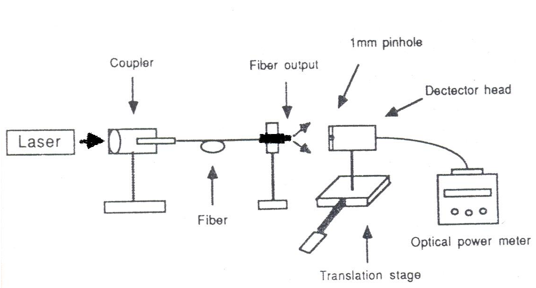

FIGURE 1. Experimental setup to measure attenuation

Attenuation in dB/m is calculated using the formula

$$\alpha = \frac{10}{L_2 - L_1}\log\left(\frac{P_1}{P_2}\right) \quad \text{in dB/m}$$

where P_1 and P_2 are maximum output of fibers of length L_1 and L_2 respectively

The experiment is repeated for the determination of attenuation by exposing fibers both (both L_1 and L_2) to β and γ sources. Results are tabulated in Table 1.

DISCUSSION AND CONCLUSIONS

As mentioned by O'Keeffe and et. al. (2007) [3], plastic optical fibers show low attenuation for red region. The fiber showed low attenuation for light of 632.8nm compared to light of 780nm.

From Table 1, it is evident that plastic optical fibers show low attenuation in visible range than IR range.

As in silica optical fibers, the radiation induced attenuation in POF is wavelength dependent and radiation induced attenuation (RIA) is more for optical region compared to IR region. The RIA in PMMA fiber may be due to separation of some of molecules from polymer chain when irradiated radiation energy interacts with material of the fiber. In visible region, POF shows attenuation of 0.3258dB/m on exposing to beta radiation. The attenuation of the fiber is 0.3287dB/m on exposing to gamma radiation. In IR region, fiber shows attenuation of 0.3359dB/m on exposing to beta radiation and 0.3362dB/m on exposing to gamma radiation. Hence, irrespective of wavelength region, the attenuation of POF is more on exposing to gamma radiation.

The radiation induced attenuation of the fiber is summerised in Table 2. In both the cases –exposing fiber to beta and gamma radiations, the RIA is more in visible region than in IR region.

From our results, we can conclude that the RIA is wavelength dependent and the attenuation is more in visible region than in IR region.

TABLE 1. Attenuation in the fiber before and after exposing to nuclear radiation in dB/m

Light Source	Without Radiation Source	With Radiation Source	
		Tl^{204} (0.746MeV) Beta Source	Na^{22} (1.274MeV) Gamma Sources
He-Ne Laser (632.8nm)	0.3236	0.3258	0.3287
IR Laser (780nm)	0.335	0.3359	0.3362

Table 2 :Radiation Induced Attenuation in Optical fiber

Light Source	For Beta Source **α- α₁ (in dB/m)**	For Gamma Source **α- α₂ (in dB/m)**
He-Ne Laser (632.8nm)	$2.2X1^{-3}$	$5.1X1^{-3}$
IR Laser (780nm)	$0.9X1^{-3}$	$1.2X1^{-3}$

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