Research of Attenuation Spectrum in Organic Optical Fiber

Shangzhong Jin [a,b*] , Wen Zhou[a] , Zaixuan Zhang [b]
a.Institute of Information Engineering, Zhejiang University, 310027,China
b. Institute of Information Engineering, China Institute of Metrology, 310034, China

ABSTRACT

The main characteristic affecting on fiber transmission are attenuation and dispersion in optical fiber. The equipment of measuring attenuation has been set up in this letter. The attenuation in some organic optical fiber is measured. The lowest losses are 238dB/km at 670nm for PS core, 197 dB/km at 580nm for PMMA core, and 0.2dB/m at 650nm for C_6H_6 liquid-core optical fiber. Temperature and ultraviolet radiation affecting on loss in fiber are researched.

Keywords: plastic optical fiber, liquid-core fiber, loss, attenuation, LANs

1. INTRODUCTION

Organic optical fibers are considered for high-performance fiber links at short distances. There are the plastic optical fibers and the liquid-core fibers.

The advantages of plastic optical fibers (POF's) have attracted much attention. POF's are easy to be handled because of their high flexibility, light weight, large core diameter and high numerical aperture. Their usage could often decrease systems costs compared to glass fibers. They are easy to connect to light sources and other components. They are expected to be the advanced short distance signal transmission medium [1][2]. In particular, a large-core, high-bandwidth, and low-loss GI polymer optical fiber (POF) is one ideal candidates to meet high speed fiber optic networks increasingly require high performance fiber links in short distance applications such as local area networks (LANs), data links, and multi-node bus networks using for home and automobile applications[3][4].

The main characteristic affecting on fiber transmission are attenuation and dispersion in optical fiber. In this letter, the equipment of measuring attenuation has been set up. The attenuation in some organic optical fiber is measured. There are the plastic optical fibers (PS(polystyrene), PMMA (polymethyl methacrylate)) and hollow quartz fiber filled the liquid (C_6H_6). The factors affecting on loss in fiber are researched, such as temperature, ultraviolet radiation.

2. MEASURING PRINCIPLE AND SETUP

2.1 Attenuation in plastic optical fiber

The core of POF includes PS(Polystyrene), PMMA (Polymethyl methacrylate), PC(Polycarbonate),fluorinated PMMA,etc. The cladding of POF includes PMMA,fluorinated PC,Teflon AF,THV, and so on. Attenuation of the signal in POFs is caused by various mechanisms. The different contributions to the total loss mechanism can be divided into intrinsic and extrinsic losses. In the UV-region of the spectrum, the losses are due to both electronic absorption, for which mainly aromatic and unsaturated groups and to a lesser extent carbonyl groups are responsible, and Rayleigh scattering. In the near-IR region large loss peaks are caused by vibrational absorptions, mostly from C-H bonds. This accounts for the fact that most POFs have low-loss windows in the visible region of the spectrum, between about 500 – 700 nm. It would be favorable to substitute the C-H bonds in the polymer (responsible for the large IR-absorption) by C-F or C-D bonds. The higher reduced masses of these groups should cause the fundamental vibrational absorption to shift further into the IR wave band, thus expanding the low-loss window.

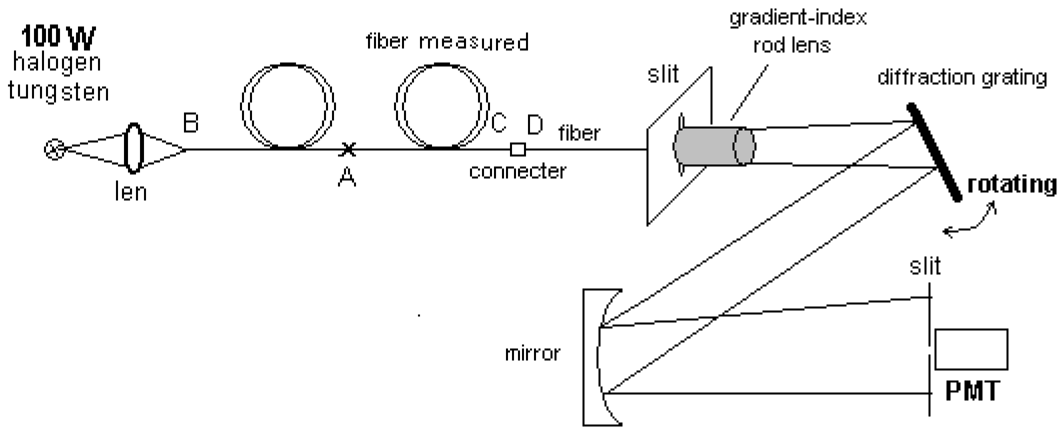

Fig.1. Diagram of measuring attenuation in POF

The system using for measure the attenuation in POF is showed in Fig.1. The light coming from a 100W halogen tungsten lamp is coupled in POF--BAC on front side B by a len. It transmits on back side C, is coupled in D side of connecting fiber (length 1m and core/clading 980 um /1000 um). It passes through a slit (100um width) and collimated into parallel light by a GRIN len. It is diffracted into multicolor light by grating and focused on sensing side of PMT(HAMAMATSU CR131) by a mirror. There is also a slit in the front of PMT.

Firstly, the spectrum transmission power $P_{OUT}(\lambda)$ of POF--BAC is measured. Secondly, the POF is cutted into two parts in point A. Side A is connected on side D, the spectrum transmission power $P_{IN}(\lambda)$ of POF--BA is measured. Side B,A and C should be polished. Therefore, the attenuation $\alpha_C(\lambda)$ of AC part POF is as follows[5]:

$$\alpha_C(\lambda) = \frac{10}{L}\log\frac{P_{IN}(\lambda)}{P_{OUT}(\lambda)} \qquad (1)$$

where L is the length of AC part POF. $\alpha_C(\lambda)$ is relative attenuation spectrum of POF,because side A is connected with side D different from side C. It should be calibrated. In Fig.2, halogen tungsten lamp and diffraction grating system are substituted for a He-Ne laser and a power meter. The loss of wavelength 632.8nm is α_{6328}. It is compared with formula (1), the

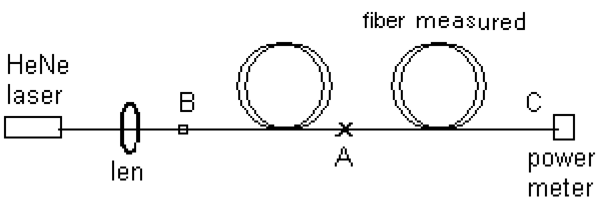

Fig.2. Loss measurement of single wavelength

calibration factor is $K = \alpha_{6328} / \alpha_C(632.8)$. So, the loss of POF $\alpha(\lambda)$ is :

$$\alpha(\lambda) = K \cdot \alpha_C(\lambda) \qquad (2)$$

its unit is dB/km.

The attenuations of fiber A(PS core PMMA cladding) and fiber B (PMMA core fluorinated PMMA cladding) are measured by using the system of Fig.1. They are showed in Fig.3. The lowest losses are 238dB/km at 670nm and 197 dB/km at 580nm for fiber A and fiber B, correspondingly.

The losses of fibers have been tested in different condition. When temperature rises from 20 to 80 centigrade, fiber A shows a little yellow, The lowest loss is from 238 dB/km to 267 dB/km, The lowest loss of fiber B is from 197 dB/km to 200 dB/km. The lowest loss is also from 238 dB/km to 278 dB/km when fiber A is irradiated in Xe lamp (at 40W/m^2) for 48 hours. Hardly does the loss of fiber B vary in this condition. PMMA is stable when used at up to +80 centigrade.

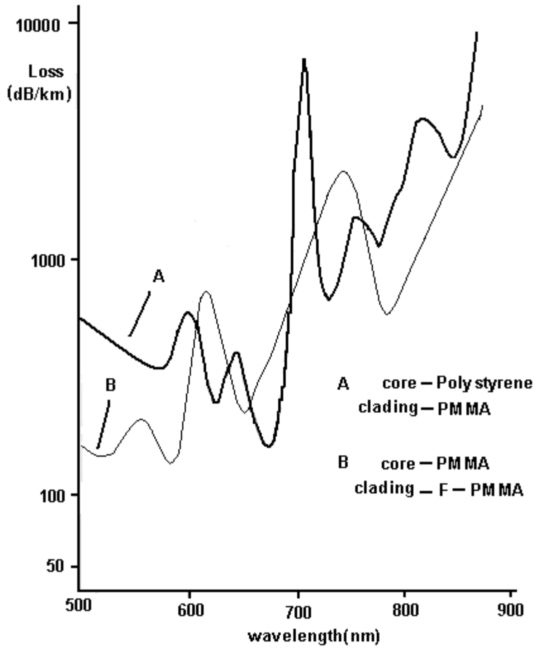

Fig.3 The attenuations of POF

2.2 Attenuaton in organic liquid-core optical fiber

The organic liquid-core fiber is composed of quartz hollow fiber filled organic solution (such as C_6H_6, CCl_4, CS_2 and so on). The hole and outer diameter of quartz hollow fiber is 8um and 125 um. Outer diameter of coating cladding is 300 um. It is consistent with single mode glass fiber, for example G652. The fiber tested is made according to following method: Two tri-connectors (showed in Fig.4) are separately connected to two sides of a 1m quartz hollow fiber. Two G652 fibers are separately connected to other sides of two tri-connectors. Organic solution is filled into the container above the third hole of right tri-connector, and the third hole of left tri-connector is connected with a vacuum pump. When the vacuum pump turns on, air is taken out, and organic solution is immitted into hollow fiber. When liquid is filled full in hollow fibe, two G652 fibers are inserted to hollow fiber, and adhibitted to tri-connectors by using expoxy. It is showed in Fig.5. LED's light is coupled into left G652, and transmission

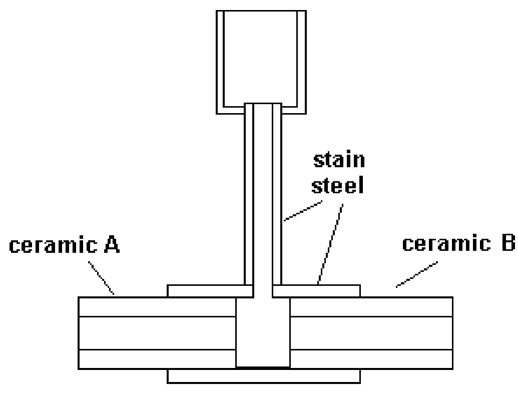

Fig.4 Diagram of tri-connector

light is measured by OSA(Adventest Q8384). The loss is measured by cutting out fiber and according to formula (1).

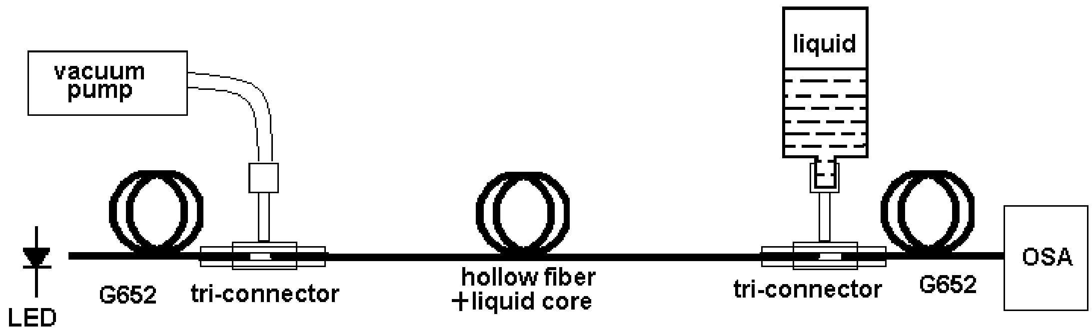

Fig.5 Diagram of loss measurement in organic liquid-core fiber

Fig.6 shows the attenuation spectrum curve of C_6H_6. The lowest loss is 0.2dB/m at 650nm. It is consistent with the result of J.Stone[6].

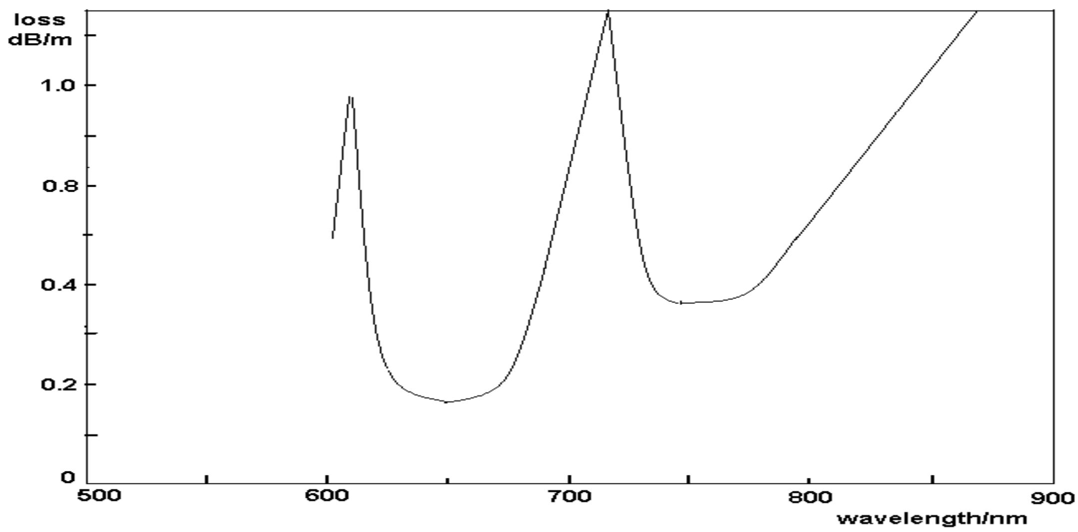

Fig.6 The attenuation spectrum curve of C_6H_6

3.CONCLUSION

We set up the systems measuring the attenuation of organic material optical fiber. The losses of PS, PMMA plastic optical fiber, and C_6H_6 liquid-core optical fiber are measured. The lowest losses are 238dB/km at 670nm for PS core, 197 dB/km at 580nm for PMMA core, and 0.2dB/m at 650nm for C_6H_6 liquid-core optical fiber. PS fiber is easy affected on by environment. PMMA is stable when used at up to +80 centigrade.

ACKNOWLEDGMENTS

The research is supported gravely by the Natural Science Foundation of Zhejiang(No.ZD0102).

REFERENCES

1. T. Kaino, M. Fujiki, and K. Jinyuji, "Preparation of plastic optical fibers" *Rev. Electron. Commun. Lab.*, **32** pp. 478–488, 1984
2. C. Koeppen, R. F. Shi, W. D. Chen, and A. F. Garito, "Properties of plastic optical fibers," *J. Opt. Soc. Amer. B*, **15**, pp. 727–739, 1998
3. Y. Koike, T. Ishigure, and E. Nihei, "High-bandwith graded-index polymer optical fiber," *J. Lightwave Technol.*, **13**, pp. 1475–1489,1995
4. T. Ishigure, M. Sato, O. Takanashi, E. Nihei, Y. Nyu, S. Yamazaki, and Y. Koike, "Formation of the refractive index profile in the graded index polymer optical fiber for gigabit data transmission," *J. Lightwave Technol.*, **15**, pp. 2095–2100, 1997
5. G.Keiser, Optical Fiber Communications, Third Edition,published by the McGraw-Hill Copanies,2000
6. J.Stone, "CW Raman Fiber Amplifier,"*Applied Physics Letters*, **26**, pp.163-165,1975

* Contact jsz63@ 163.net; phone 86-571-85024586; fax 86-571-85028409