Research on transmission character of side polished fiber

YAN Lu, WANG Guan-jun, AN Yong-quan, WANG Zhi-bin, GUI Zhi-guo

(*School of Information and Communication Engineering, North University of China, Taiyuan 030051, China.*)

Abstract: Transmission characteristics of the side polished fiber were studied by experimental method. The side polished fibers with different depth and length were implemented, and the corresponding wavelength dependent loss was measured. Based on wheel fabrication, the side polished fibers were achieved with the low insertion loss and cost. Meanwhile, they can be artificially controlled for the use of evanescent field area and easy to system integration.

Key words: side polished fiber; optical fiber sensing; attenuation of optical power

CLD number: TN253 **Document code**: A

Article ID: 1674-8042(2016)02-0145-04 **doi**: 10.3969/j.issn.1674-8042.2016.02.008

0 Introduction

Since the 1970s, with the rapid development of science and technology, attention of the optical fiber communication technology with the carrier of optical fiber has been widely paid in the field of scientific research and practical life, not just in the optical fiber communication industry. Because of its fast response speed, strong ability to resist electromagnetic interference, high sensitivity, easy to integration, small volume, low cost, high security and other irreplaceable advantages[1], the position of sensor is becoming important. As the forerunner of sensing technology, the optical components on the basis of the optical fiber material is being more and more popular, one of which is the side polished fiber (SPF) that can produce a variety of all-fiber device basic optical elements[2-4].

In the late 1970s, SPF can be cast. Thirty years ago, R. A. Bergh take silica radical into a arc slot, glue the optical fiber, and then put the optical fiber on the machine to polishing[5]. This method make the SPF has a big volume and complicated preparation process, easy to break, but the polishing grinding area is not flat, the shortcomings are high cost and low yield[6-7].

In view of the above shortcomings, using precision optical processing technology, SPF is made by wearing off ordinary fiber cladding of the optical fiber, and its structure diagram is shown in Fig. 1.

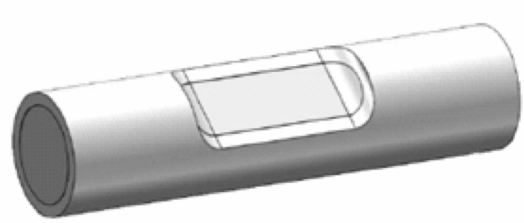

Fig. 1 Structure of SPF

SPF is naked in ordinary single-mode optical fiber in a certain area, by one-side polishing cladding of fiber core, the cladding polished off part is made of a fiber, whose cross-sectional is shaped like English letter D[8-9], and the section without grinding is still a

Received date: 2015-03-08

Foundation items: National Natural Science Foundation of China (No. 61405127); Shanxi Province Science Foundation for Youths (No. 2014021023-1); Scientific and Technologial Innovation Programs of Higher Education Institutions in Shanxi and the Program for Top Young Academic Leaders of Higher Learning Institutions of Shanxi

Corresponding author: AN Yong-quan (852122461@qq.com)

cylindrical, the profiles are presented as Fig. 2.

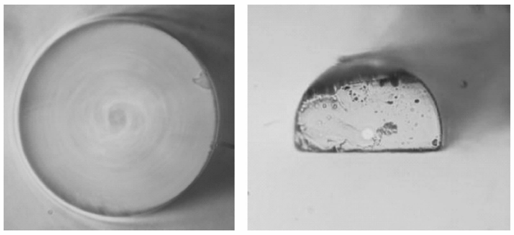

Fig. 2 Before and after side polishing process

Wear off the single-mode fiber cladding side part, light will be easy to leak out from the optical fiber core if the remaining cladding thickness is small. Cover the SPF surface with materials of different refractive index, which can cause the change of light transmission in the fiber core and optical power[10]. Although the SPF is structurally similar to D type optical fiber[11], it has more advantages than the traditional D type optical fiber, such as its simple production process, cost savings, low price, etc. So the SPF can be made into optical fiber devices and sensors, and it has become one of the indispensable material and optical element[12-13].

1 Theory base

Guided modes in optical fiber occur total reflection at the interface of the fiber core and cladding. Most of the energy is concentrated in the fiber core, but part of the energy will permeate into the cladding and the external environment, and it is a kind of strength along the fiber radial exponential attenuation of electromagnetic wave, which is called as evanescent field of the fiber[14]. Suitable thickness of the optical fiber cladding can ensure the transmission of the light field in the fiber core. When polishing or chemical etching makes the cladding thickness decreases to the evanescent wave field exist, which the distance from fiber core is only a few microns, a light transmission in the core of the evanescent wave field "leakage window" is formed[15]. Fiber core closer to the external environment, the more energy will permeate, the interaction between the outside and optical fiber will be stronger. Due to the SPF structure of non-circular symmetry, it is more close to the outside environment compared with the conventional single mode fiber core, so the interaction of outside world and the optical fiber is better than that of ordinary single mode optical fiber. It makes the SPF can be applied to energy coupling, refractive index sensing, bending sensing and so on[16].

2 SPF transmission characteristics

As Fig. 3 shown, one end of SPF connects to the light source, another end connects to the optical power meter, for measuring the transmission characteristics. Keep the power of light source output and wavelength unchanged, replace the different residual thickness of the cladding fiber, study the change of the optical fiber transmission of optical power.

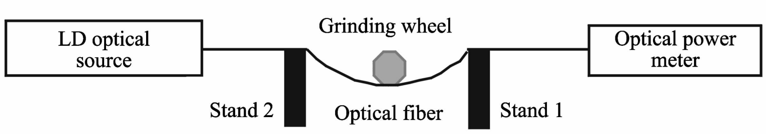

Fig. 3 Schematic diagram of SPF

2.1 Effects of film thickness d on the transmission characteristics of optical fiber

The SPF used in the experiment of the side length of grinding zone is 10 mm, the residual thickness of cladding is 91, 79 and 74 μm, as Fig. 4 shown.

Under the same situation, use of optical power monitoring equipment, examine side profile grinding fiber with different d, measure the relationship between transmission light power loss and d of the side polished optical fiber. The d is measured by diameter measurement and control system with high precision. The input optical power $I_0 = 0$ dBm, polishing zone length $L_p = 10$ mm, grinding wheel granularity is 7 000, the experiment result is shown in Fig. 5. When $d < 45$ μm, optical power loss is less than 5 dBm, while when $d > 45$ μm, loss increases obviously. In the case of $d \approx 60$ μm, optical loss up to 30 dBm.

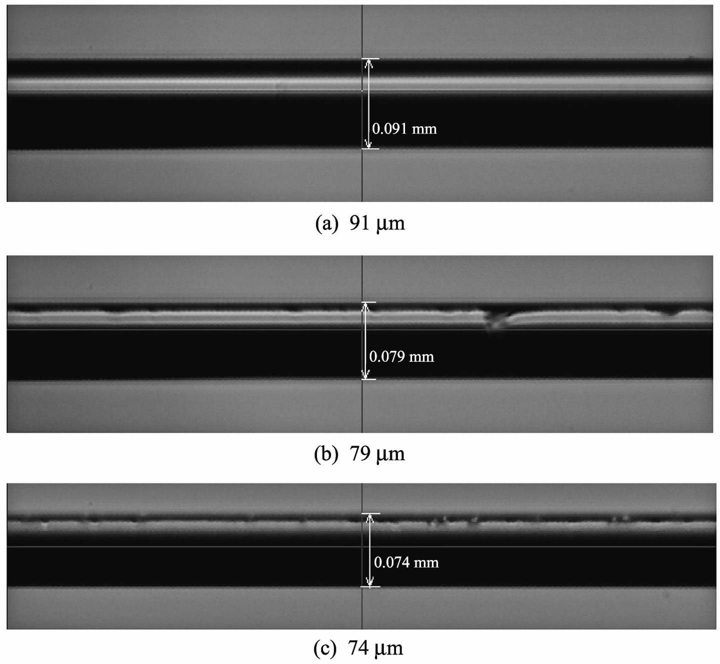

Fig. 4 Different depth of film

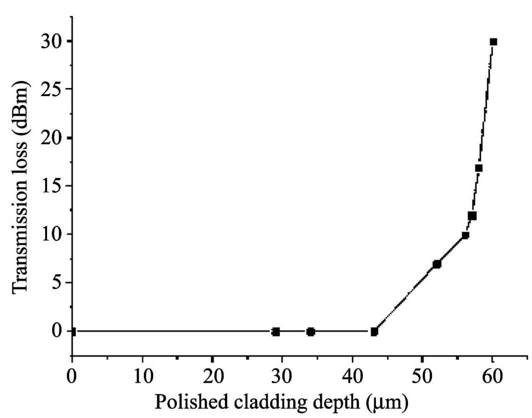

Fig. 5 Relation between polished cladding depth and transmission loss

2.2 Effects of sand paper roughness on the optical fiber polishing film

In order to study the influence of optical transmission characteristics of profile grinding surface roughness, the sand papers with granularity of 3 000 and 12 000 were used respectively. Visible surface of SPF by 3 000 granularity sand paper coarse grinding is very rough, light scattering is big, two bright streaks of fiber core almost can't be seen clearly. Using the sadpaper with granularity of 12 000 grinding of optical fiber, the layer of the cladding is also seen clearer, there is no astigmatism point throughout the polishing surface, which shows that the grinding surface roughness is small. When the polishing zone length $L_p = 10$ mm, the influence of the polishing roughness optical transmission characteristics is shown in Fig. 6. Experimental results show that the rougher grinding surface the greater the attenuation of the light.

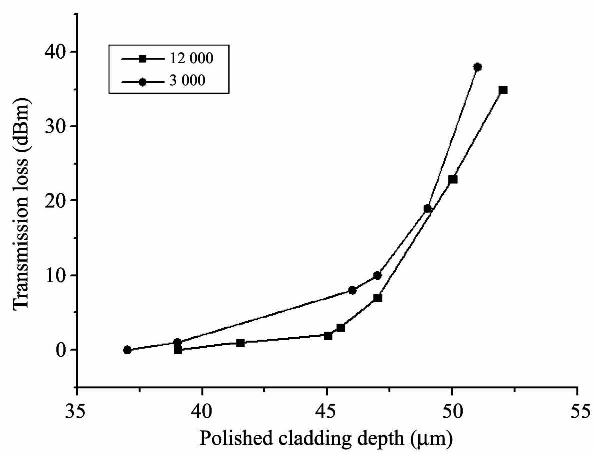

Fig. 6 Effect of roughness on optical transmission properties

3 Conclusion

SPF is low cost, small size and has unique optical properties. It can be made for the new type of optical fiber devices. People need different grinding length and depth of side grinding fiber. The theoretical support and experimental evidence are all necessary.

This article provides the basis for production of new all-fiber device by studying the optical transmission characteristics of the SPF.

References

[1] Chiu M H, Chiu P C, Hsien L Y, et al. Multimode D-type optical fiber sensor based on ATR effect in temperature detection. Sensors & Transducers, 2009, 111(12): 125-131.

[2] LIU Lin-he, CHEN Zhe, BAI Chun-he, et al. The effect of refractive index of material overlaid side polished area of FBG on Bragg wavelength. Acta Photonica Sinica, 2007, 36 (5): 865-868.

[3] ZHANG Yun-cong, CHEN Zhe, JIANG Pei-fan, et al. All-fiber thermooptical variable optical attenuator. Chinese Journal of Lasers, 2007, 34(8): 1110-1114.

[4] XIAO Ya-ting, CHEN Zhe, ZHANG Ling-tong, et al. All fiber online optical power monitor based on side-polished fiber. Journal of Applied Optics, 2010, 31(4): 620-625.

[5] Slavik R, Homola J, Ctyroky J, et al. Novel spectral fiber optic sensor based on surface plasmon resonance. Sensors and Actuators B: Chemical, 2001, 74(1): 106-111.

[6] Piliarik M, Homola J, Manikova Z, et al. Surface plasmon resonance sensor based on a single-mode polarization-maintaining optical fiber. Sensors and Actuators B: Chemical, 2003, 90(1): 236-242.

[7] JING Ning, TENG Chuan-xin, YU Fang-da, et al. Temperature dependence of a refractiveindex sensor based on side-polished macrobending plastic optical fiber. IEEE Sensors Journal, 2016, 16(2): 355-358.

[8] Santos D F, Guerreiro A, Baptista J M. Numerical investigation of a refractive index SPR D-Type optical fiber sensor using COMSOL multiphasics. Photonic Sensors, 2013, 3(1): 61-66.

[9] Qazi H H, Mohammad A B, Ahmad H, et al. Single-mode D-shaped optical fiber sensor for the refractive index monitoring of liquid. Journal of Modern Optics, 2016, 63 (8): 750-755.

[10] Maler S A. Plasmonics: fundamentals and applications. New York: Springer Science & Business Media, 2007.

[11] Ong Y S, Kam W, Harun S W, et al. Low-cost transducer based on surface scattering using side-polished D-shaped optical fibers. IEEE Photonics Journal, 2015, 7 (5): 1-10.

[12] CHEN Zhe, LIU Lin-he. Temperature compensation of fiber bragg grating based on side polishing and overlay. Chinese Journal of Lasers, 2008, 35(6): 889-892.

[13] JIANG Pei-fan, CHEN Zhe, ZENG Ying-xin, et al. Investigations on optical transmitting characters of side-polished fibers. Semiconductor Opto-Electronic, 2006, 27 (5): 578-581.

[14] Jung J H, Kim M W. Optimal design of fiber-optic surface plasmon resonance sensor. Journal of the Optical Society of Korea, 2007, 11(2): 55-58.

[15] Dwivedi Y S, Sharma A K, Gupta B D. Influence of design parameters on the performance of a surface plasmon sensor based fiber optic sensor. Plasmonics, 2008, 3(2-3): 79-86.

[16] Sharma A K, Mohr G J. On the performance of surface plasmon resonance based fibre optic sensor with different bimetallic nanoparticle alloy combinations. Journal of Physics D: Applied Physics, 2008, 41(5): 055106.

侧边抛膜光纤传输特性的研究

严　璐，王冠军，安永泉，王志斌，桂志国

（中北大学 信息与通信工程学院，山西 太原 030051）

摘　要： 本文通过实验的方法了解侧边抛磨光纤的传输性能，深度研究了不同抛磨深度、不同抛膜长度的侧边抛磨光纤，测量了不同抛磨深度光纤存在着波长相关损耗。本文利用轮式侧边抛磨法制作侧边抛磨光纤，具有插入损耗较低、成本低廉、可人为控制对倏逝场区域的利用、易于系统集成等特点。

关键词： 侧边抛膜光纤；光纤传感；传输特性

引用格式： YAN Lu, WANG Guan-jun, AN Yong-quan, et al. Research on transmission character of side polished fiber. Journal of Measurement Science and Instrumentation, 2016, 7(2): 145-148. [doi: 10.3969/j.issn.1674-8042.2016.02.008]