The correlation coefficient method for alignment of polarization maintaining fiber

Jun Zhang, Jianhui Yu, Jieyuan Tang, Mengyuan Xie
Key Laboratory of Optoelectronic Information and Sensing Technologies of Guangdong Higher Educational Institutes
（Jinan University）
Guangzhou 510632, CHINA
ccdbys@163.com

Fengli Li, Furong Huang, Zhe Chen*
Department of Optoelectric Engineering
Jinan University
Guangzhou 510632, CHINA
thzhechen@jnu.edu.cn

***Abstract*—The paper introduces the aligned method of polarization maintaining fiber (PMF) combined the characteristic value methods with the correlation coefficient method. This method is based on side-view of fiber. The PMF is irradiated by parallel ray from lateral side and the observation plane where set a camera is on the other side. The side-view of PMF from the camera is intercepted to get the light-intensity distribution of fiber cross section. Because the curve of the light-intensity distribution is changed when the PMF is rotated around the fiber core, and the results of simulation and experiment shows that the correlation coefficient of the curve can be used to align PMF and the speed of alignment is improved with the correlation coefficient method.**

Keywords*—*Polarization maintaining fiber (PMF); side-view; correlation coefficient

I. INTRODUCTION

In fiber optics, polarization maintaining fiber (PMF) is optical fiber in which the polarization state of linearly-polarized light waves launched into the fiber is maintained during propagating along the fast and the slow axes with minimum coupling and not be affected by external turbulence[1-2]. PMF have found many applications ranging from telecom, sensor (gyroscope), and lab measurements. The key technology in PMF applications is how to align PMF. At present, the side-view imaging methods mainly include Ericsson POL Method (Polarization Observation by Lens-effect-tracing Method)[3], Fujikura's direct monitoring method using a central image[4], phase contrast imaging method[5], backward diffractive patterns method[6] and finger-type intensity distribution characteristic value method[7]. In this paper the speed of alignment is improved when we use the correlation coefficient method to align the PMF.

II. SIMULATED MODEL OF PMF

Standard panda fiber model is established as shown in Fig. 1, and Advanced System Analysis Program (ASAP™) is used to simulate parallel light beams irradiate the PMF and trace the rays. In Fig. 1, PMF is seen as a lens, the axis across the two stress zones is called slow axis, and the vertical axis is known as fast axis which is through the fiber core. The parameters are set including 1) the refractive index of PMF core n_1=1.46878, the radius r_1=3μm; the refractive index of envelope n_2=1.4573, the radius r_2=62.5μm; the refractive index of stress zone n_3=1.44388, the radius r_3=13μm; the distance between the two stress zone center d=42μm. The different azimuth in calculation program can be gotten by the rotation of PMF.

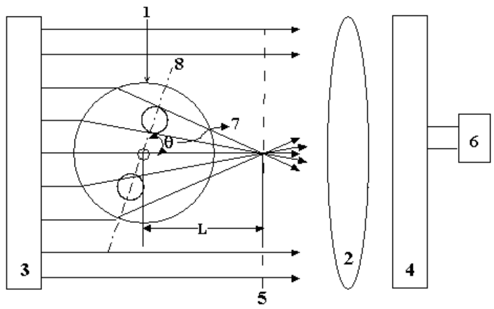

Fig. 1. The schematic drawing of PMF model. 1: Fiber, 2: Len, 3: Light source, 4: CCD, 5: Observation plane, 6: Computer, 7: Azimuth of slow axis, 8: Slow axis.

III. RESULTS AND DISCUSSION

Fig. 2 is a simulated figure and a CCD figure of PMF, the intensity distribution curve of PMF cross section is along with the straight line in figure. It demonstrates that the simulation model is correct.

Fig. 3 is the simulation results of intensity distribution curve when the observation distance L is 151μm and θ is 86°, 90° and 94°. There are 9 characteristic points on the curve, and their intensity are marked as P1, P2, P3, P4, P5, P6, P7, P8 and P9 from left to right. We can calculate the characteristic value as follows: P5-|P1-P9|-|P2-P8|-|P3-P7|-|P4-P6|. By comparing the characteristic value we can align the axis of PMF. However, this method needs the 9 point of the curve.

We find that the intensity distribution curve of PMF side-view has some symmetry. So if the center of the fiber or the point 5 in Fig. 3 can be found, we can use (1) to calculate the correlation coefficient R of the curve.

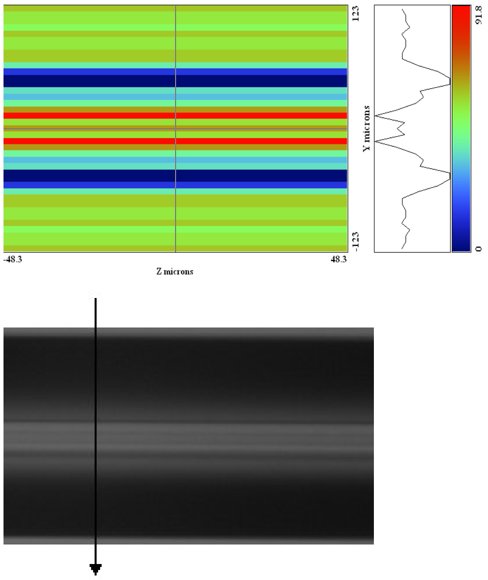

Fig. 2. False color simulated figure of PMF (up) and a CCD figure of PMF (down).

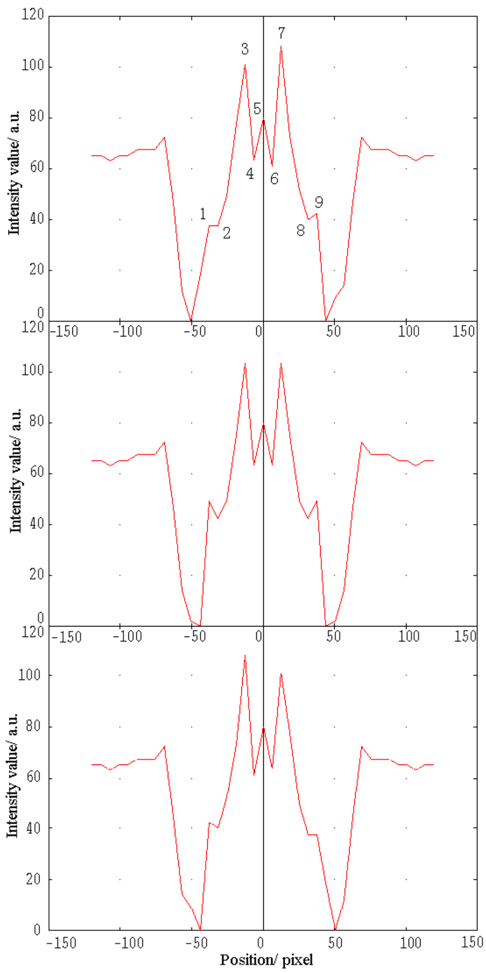

Fig. 3. The simulation results of intensity distribution curve when the observing distance L=151μm and θ=86°(up), 90°(middle)and 94°(down).

$$R = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})\sum_{i=1}^{n}(y_i - \bar{y})}} \tag{1}$$

To (1) point 5 in Fig. 3 is set as the center, n-pixel is taken from the left side of the point P5 and the intensity values is marked as $x_1, x_2, \ldots x_n$; another n-pixel is taken from the right side of the point P5 and the intensity values is marked as $y_1, y_2, \ldots y_n$.

The results of simulation and experiment show that the change of correlation coefficient R value can be used to align the axis of PMF.

IV. CONCLUSIONS

With ASAP software the ray tracing model of PMF is established. The intensity distribution curve of PMF side-view is used to get the characteristic points and the correlation coefficient of the curve. The results of simulation and experiment show that the change of correlation coefficient R value can be used to align the axis of PMF. Moreover to automatic alignment of PMF, the correlation coefficient method can improve the alignment speed because only center point need to be find before comparing the correlation coefficient value.

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