Numerical Analysis of Optical Coupling Characteristics of Side-polished Photonics Crystal Fiber and Micro Optical Fiber with Bending

Xiaoli He[2], Jianhui Yu[1,2], Yingxin Zeng[2], Yunhan Luo[1,2], Jun Zhang[1,2], Jieyuan Tang[2], Zhe Chen[1,2], Huihui LU[1,2]*
[1]Key Laboratory of Optoelectronic Information and Sensing Technologies of Guangdong Higher Education Institutes(Jinan University), Guangzhou, China
[2]Department of Optoelectronic Engineering, Jinan University, Guangzhou, China
*thuihuilu@jnu.edu.cn

***Abstract*—In order to design all optical fiber coupling devices based on side-polished photonics crystal fiber(SPPCF) and micro optical fiber(MF), a numerical model was utilized by use of three dimension finite difference beam propagation method (FDBPM). The optical coupling characteristics between SPPCF and MF were calculated and analyzed with the variation of the three factors: residual radius after side polishing, the diameter of the MF, and the radius of curvature of MF's bending part.The numerical study shows: when the launch light input from MF, the shorter the residual radius of SPPCF is, the larger the optical power, which is coupled into SPPCF. The diameter of the MF and the residual radius after side polishing were also optimized according to the optical transmitted power throught the coupled device by combinning the SPPCF and MF.**

Keywords—Side-polished fiber; Photonics Crystal Fiber; finite difference beam propagation method; the optical power; coupling;

I. INTRODUCTION

The research of photonics crystal fiber and its device have become hot spots in the optical communications and optoelectronic field due to their excellent optical properties [1]. Optical microfibers have been intriguing due to its strong confinement of light in the micro or nanoscale[2], leading to enhancement of the interaction with material.

In recent years, side-polished photonics crystal fiber has been reported to analyze its optical propagation characteristics [3]. Many devices based on SPPCF were reported, such as Tunable Photonic Crystal Fiber Coupler for Nonlinear Optical Microscopy [4], tunable photonic crystal fiber coupler, fiber sensors. However, the coupling device between the PCF and MF have not been reported. In this paper, the theoretical coupling model between SPPCF and MF with bending part is established by 3D-FDBPM and the coupling characteristics about the coupling device are analyzed.

II. THROETICAL COUPLING MODEL OF SIDE-POLISHED PHOTONICS CRYSTAL FIBER AND MICROFIBER

The theoretical coupling model of SPPCF and MF is established as shown in Fig.1. The residual radius R represents the distance between the center of fiber and the side-polished surface; D means the diameters of MF; r means the radius of curvature of MF's bending part.

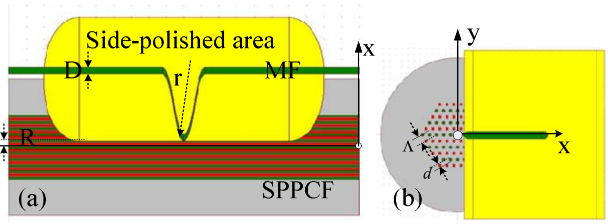

Fig.1.The theoretical coupling model of SPPCF and MF (a) Longitudinal cross-section of optical model;(b) Transverse cross-section of optical model

III RESULTS AND DISCUSSIONS

In the simulation, the optical power transmits along the Z axis, and optical power transmittance T is the ratio of the output optical power to the input optical power when light pass through the coupling device. The launch power of the theoretical model is Gaussian beam.

Fig.2 shows that when the diameters of MF is 9μm, the optical power transmittance T which is coupled into SPPCF changes with the variation of the residual radius R and the radius of curvature of MF's bending part. The shorter the residual radius of SPPCF is, the larger the optical power transmittance T is obtained. When the radius of curvature of MF's bending part vary from 270μm to 1500μm, the optical power transmittance T increases firstly, and then decreases as displayed in fig 2.

Fig.3 shows that when the R=3.5μm, with the variation of diameters of MF D from 6μm to 12μm, the optical power transmittance T which is coupled into SPPCF increases firstly, and then decreases. The optimized optical transmitted power is obtain when the diameters of MF D are 9μm, which signifies the coupling efficiency is much higher. Fig.4 shows that when R=3.5μm and D=9μm, the cross-sectional refractive index distribution of coupling model at z=5000μm; h_0 means the distance from the side-polished surface to the nearest air hole in the center line.

IV CONCLUSION

Optical coupling characteristics of side-polished photonics crystal fiber and micro optical fiber with bending have been analyzed. The optical power transmittance T which is coupled into SPPCF were calculated and analyzed with the variation of the three factors, such as: residual radius after side polishing, the diameter of the MF, and the radius of curvature of MF's bending part. The results can be used to optimized the optical transmitted power by utilizing appropriate residual radius of SPPCF、the diameter of the MF and he radius of curvature of MF's bending part.

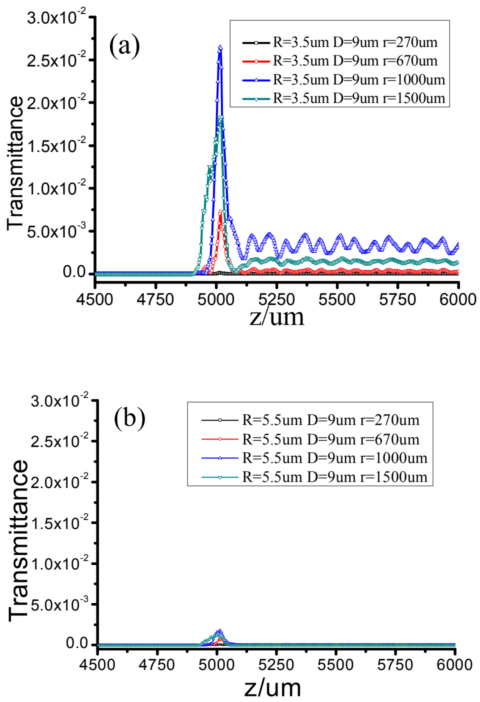

Fig.2 The optical power transmittance T which is coupled into SPPCF when D=9μm (a) when R=3.5μm; (b) when R=5.5μm

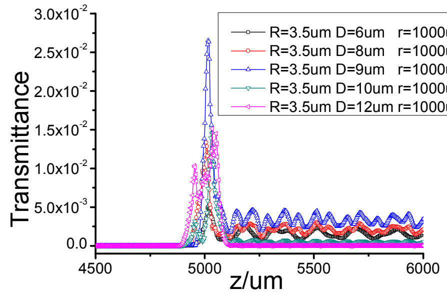

Fig.3 The optical power transmittance T which is coupled into SPPCF when R=9μm,r=1000μm

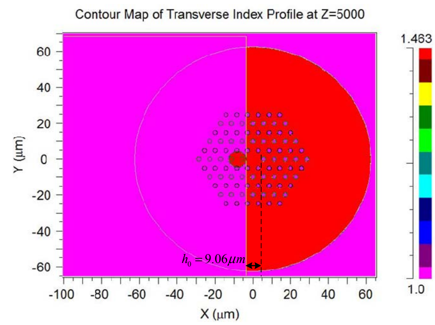

Fig.4 The cross-sectional refractive index distribution of coupling model where z=5000μm

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