Optimization of Polished Angle for Optical coupler based on Side-Polished Photonic Crystal Fiber

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***Abstract*-In order to design couplers based on side-polished photonic crystal fiber (SPPCF), we made the simulation and calculated the polished angle. A model of coupling region of SPPCF coupler was established. The optical propagation characteristics of SPPCF coupler was calculated with different angles by using the software Rsoft. The simulation shows that light field appeared alternately between two optical fibers of coupler and there was coupling effect. When the angle was 0°, it could provide the best design for the objective coupling ratio of 50%, because the relatively longer coupling period gives more convenience to fabricate a PCF based fiber coupler.**

I. INTRODUCTION

Optical couplers, which are used to bond or split the power of different channels, are components of extreme importance in optical communication systems [1]. The side-polished photonic crystal fiber (SPPCF) is fabricated from the photonic crystal fiber (PCF) with the cladding part removed[2]. The "window" of transmission light in PCF is formed on the polished area [3-5].

Due to the intensive interest of PCF application, a tunable photonic crystal fiber coupler based on a side-polishing technique was made by Hokyung Kim [6], but there is no analysis of the optimum residual radius. It is necessary to simulate and analyze the optical propagation characteristic of SPPCF coupler with different rotation angle.

II. MODEL OF SPPCF COUPLER

Fig.1 shows the model of SPPCF coupler. In the model, d indicates the distance diameter of the air hole, Λ indicates the distance between centers of adjacent air hole, n_{air} and n_{cl} indicate the refractive index of air hole and that of PCF's materials, respectively [7], R indicates the residual radius. An orthogonal coordinate is set as shown figure 1 (c). the diagonal of the hexagon is denoted as x_1 axis, and y_1 axis is perpendicular to the direction of y_1. The angle between the x and x_1 axis is denoted as θ.

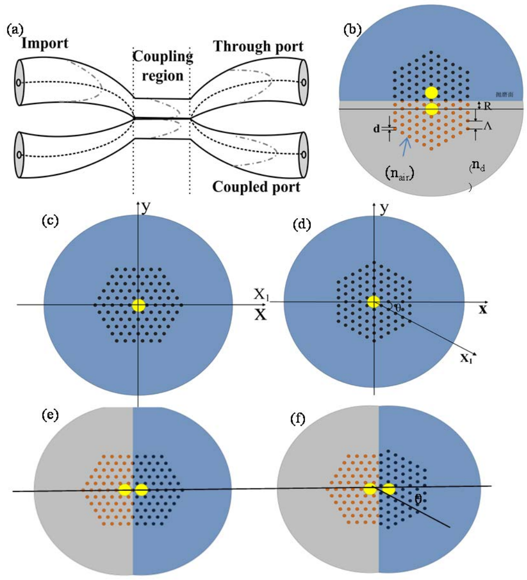

Fig.1. Model of SPPCF coupler: (a) Structure of SPPCF; (b) Cross section of the model; (c) Polish angle θ=0° ;(d) Polish angle θ=30° ;(e) Polish angle of photonic crystal fiber coupler θ=0°;(f) Polish angle of photonic crystal fiber coupler θ=30°

In the simulation, d = 2.28μm, Λ= 5.7μm, n_{cl} = 1.45, and the outer diameters of the PCF is 125μm. The free space wavelength of light is 1.55μ m.

III. RESULTS AND ANALYSIS

In the simulation, the beam propagation method simulations are performed using a commercial software package, Rsoft-Beamprop (RSoft Design 2010). Full transparent boundary condition (FTBC) is used. The light is launched with LP_{01} mode at the import, and propagates along

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the z direction [7]. Because of single-mode transmission characteristic of PCF, there is only LP_{01} mode on the cross section of through port. But the side-polishing of PCF destructs the symmetric periodical configuration in cross section of PCF. Hence single-mode transmission characteristic of PCF is changed [8]. In the simulation, we monitor the optical power of LP_{01} mode only.

We set the value of θ to be 0°, 5°, 10°, 15°, 20°, 25° and 30°, respectively. The optical power in two fibers of SPPCF coupler is calculated in the seven cases. SPPCF1 and SPPCF2 are the through port and coupled port, respectively.

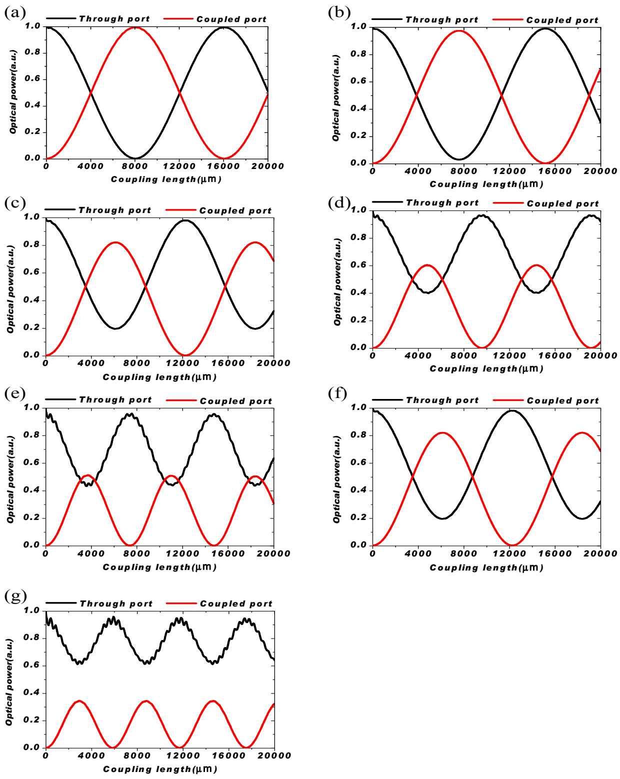

Fig.2. Optical power in two fibers of SPPCF coupler: (a) θ=0°; (b) θ=5°; (c) θ=10°; (d) θ=15°;(e) θ=20°;(f) θ=25°;(g) θ=30°

The optical power in two fibers of SPPCF coupler changes is shown in Fig.2. The coupling period is about 16000 μm, 1400 μm, 12000 μm ,8500 μm,4800 μm,1100 μm and 4500 μm, respectively.

The fact that power alternately distributes between two fibers in the coupling region can be concluded from Fig.2. When θ is 30°, coupling period is the minimum, the optical field propagates frequently between two fibers. The coupling ratio can be readout as 47%, 70%, 70%, 5%, 32%, 13%, 32% from Fig. 2 (a) – (g), respectively. When the objective CR is set as 50%, the case shown in Fig. 2(a) has the closest CR of 47%, where the grinding angle is 0 ° and the residual radius is 5.7μm.

IV. Conclusions

In summary, the grinding angle exerts an effect on the light distribution in the two coupled fibers, coupling ratio and coupling period as well. As the polished angle increases, the coupling period becomes shorter. When θ=0° and θ=5°, it could provide the best design for the objective coupling ratio of 50%, because the relatively longer coupling period gives more convenience to fabricate a PCF based fiber coupler. The simulation work is expected to be helpful to the fabrication of other PCF based devices.

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