Optimization of The Residual Radius of The Side-Polished Photonic Crystal Fiber Coupler

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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 optimum residual radius. A model of coupling region of SPPCF coupler was established. By using Rsoft software, optical propagation characteristics of SPPCF coupler was calculated with different residual radius. The simulation showed that light field appeared alternately between two optical fibers of coupler and there was coupling effect. When the residual radius was 2.85 μm or 3.99 μm, coupling effect was more obvious.

I. INTRODUCTION

Optical couplers, which are used to combine 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 [3-6].

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 [7], 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 residual radius.

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, nair and ncl indicate the refractive index of air hole and that of PCF’s materials, respectively [8], D indicates the residual radius (the minimum distance between side-polished surface and the center of PCF). Let the cross section of SPPCF coupler to be the x-y plane, and the transmission direction of light to be the direction of z axis.

In the simulation, d = 2.28μm, Λ = 5.7μm, nair = 1.45, and the outer diameters of the PCF is 125μm. The free space wavelength of light is 1.55μm.

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 LP01 mode at the import, and propagates along the z direction [8]. Because of single-mode transmission characteristic of PCF, there is only LP01 mode on the cross section of through port. But the side-polishing of PCF
detracts the symmetric periodical configuration in cross section of PCF. Hence single-mode transmission characteristic of PCF is changed [9]. In the simulation, we monitor the optical power of LP_{01} mode only.

We set the value of \( D \) to be 2.85 \( \mu \)m, 3.99 \( \mu \)m, 5.7 \( \mu \)m and 6.84 \( \mu \)m, respectively. 2.85 \( \mu \)m is half of the distance between centers of adjacent air hole, 3.99 \( \mu \)m is the distance of radius of air hole added on the basis of 2.85 \( \mu \)m, 5.7 \( \mu \)m is the distance between centers of adjacent air hole and 6.84 \( \mu \)m is the distance between centers of adjacent air hole added on the basis of the radius. The optical power in two fibers of SPPCF coupler is calculated in the four cases. SPPCF1 is through port, and SPPCF2 is coupled port.

![Optical power in two fibers of SPPCF coupler](image)

The optical power in two fibers of SPPCF coupler changes as shown in Fig.2. The coupling period is about 1000 \( \mu \)m, 1250 \( \mu \)m, 16000 \( \mu \)m and 30000 \( \mu \)m, respectively.

The fact that power alternately distributes between two fibers in the coupling region can be concluded from Fig.2. When \( D \) is 2.85 \( \mu \)m, coupling period is the minimum, the optical field propagates frequently between two fibers. When \( D = 2.85 \mu m \), optical power of the through port and coupled port can transform completely. When \( D = 5.7 \mu m \) or 6.84 \( \mu \)m, coupling period is very long.

IV. CONCLUSIONS

The greater \( D \) is, the greater coupling period is, and the smaller times of coupling per unit length is. When \( D = 2.85 \mu m \) or \( D = 3.99 \mu m \), the power in two fibers transforms frequently which provides higher success rate for coupling. When \( D = 5.7 \mu m \) and \( D = 6.84 \mu m \), because of longer coupling period, two parameters are not suitable practically. Hence the value of \( D \) can be 2.85 \( \mu \)m or 3.99 \( \mu \)m.

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