Abstract—A polarization preserving single-mode microfiber was successfully fabricated by a flame brushing method. A polarization extinction ratio of 16dB is typically maintained through the device with excess loss of 0.2dB.

I. INTRODUCTION

With recent advances in micro- and nanophotonics, optical Micro-/Nanofibers with diameters close to the wavelength of guided light have attracted considerable attention as promising building blocks for a variety of photonic applications [1-2]. The most interesting issue is the fabrication of polarization maintaining (PM) microfibers since unwanted changes in the polarization of the propagating signal induce a considerable deterioration of micro-system sensitivity. There are two principle approaches for the manufacture of PM microfibers. The first approach uses non-circular fibers such as side-flat fibers. By breaking the circular symmetry observed in conventional optical fiber tapers, a strong form birefringence can be achieved. The second approach involves the use of commercial PM fibers such as panda and bow-tie fibers. By carefully controlling the parameters of microfiber manufacture, it should be possible to control the diffusion of dopants in the tapered region and minimize the anisotropic external perturbations for preserving a given state of polarization. In this paper, a commercial panda fiber was employed as a host fiber to preserve the plane of polarization of the light and was tapered into a very thin waist (~1 μm) microfiber. The optical properties of the PM microfiber were examined by observing the polarization extinction ratio and state of polarization measurement.

II. FABRICATIONS AND OPTICAL CHARACTERIZATIONS

Figure 1(a) shows the schematic configuration of the proposed polarization maintain microfiber. A short section of panda fiber was heated and stretched into a very thin microfiber similar to previous well-established bi-conical fiber taper [2]. In the adiabatic taper transition, the local fundamental core mode ($LP_{01}^{core}$) is continuously mode converted to a guided cladding mode ($LP_{01}^{clad}$) in the taper waist by the down-taper and then coupled back into fundamental core mode ($LP_{01}^{core}$) of the fiber by the up-taper [3]. In this type of polarization preserving fiber stress applying parts induce tensile stress to the core and cause a difference in the refractive indices between the linearly polarized components that are parallel to the fast and slow axes. The linear polarization of those two lights is maintained while they propagate in the fiber, even when the fiber is bent or twisted. The main focus of this study is how well the input polarization state is preserved during the tapering process. First, the taper cross section was inspected under optical microscope using a conventional cleaving tool (diamond scribe). As shown in Fig. 1(b), the fiber geometry is well preserved and the stress applying parts are well observed even though the outer diameter is less than 10μm.

To investigate the modal guidance, in-situ transmission spectra of the PM microfiber were recorded for various outer diameters during the tapering process. An incoherent white light source and an optical spectrum analyzer were used to measure the spectral characteristics of the PM microfiber. Figure 2 shows the spectral output...
of tapered PM fibers for different diameters in the uniform waist region. Just as in similar previous experiment on high-order mode filtering in a standard telecom fiber [3], the transition region is adiabatic for fundamental mode but non-adiabatic for higher-order core mode. Note that for the microfiber with \( a = 1 \mu m \) the optical loss in the single mode region is negligible (< 0.2dB at \( \lambda = 1.55 \mu m \)).

To verify the polarization maintaining property of PM microfibers, we compared them with regular single mode (SM) microfibers with the approach of polarization extinction ratio (PER) measurement. The PER is defined as \( \text{PER} = 10 \log \left( \frac{P_{\text{max}}}{P_{\text{min}}} \right) \) and a cross-polarizer method was adapted. In this method, polarized light is launched into the core of the constituent fibers through a polarizer of which the polarization axis is aligned to one of the principal axes of the fiber. The output light is measured through an analyzer. To achieve good measurement accuracy, we chose a broadband ASE source with bandwidth up to 60nm and accurately aligned the principal polarization axes to the input PM fiber.

As shown in Fig. 3(a), single mode (SM) microfiber can exhibit a high PER at a certain angle, where one of the birefringent axes is well aligned with the polarization direction of incident light. However, transmission in regular SM microfiber was easily changed by external perturbations such as bending and twisting and the PER value was significantly deteriorated. For the PM microfiber, when stress was applied, the PER with respect to input polarization angle showed a nice polarization maintaining characteristics with a tolerance of bending stress, as shown in Fig. 3(b).

III. CONCLUSIONS

We have verified the polarization maintaining property of PM and regular SM microfibers with approach of PER and SOP measurements. Both microfibers exhibit a good capability to maintain linear polarization. However, under the presence of external perturbations such as bending, the PM microfiber exhibits consistent PM characteristics, while the SM polarization maintaining capabilities deteriorate. Therefore, PM microfibers have the potential to introduce an additional degree of control in micro-/nanophotonics.

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