Fabrication and characterization of micro-structured polymer optical fibers

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Abstract: Single-mode micro-structured polymer optical fibers over the wavelength range of 633 through 1550 nm are fabricated and characterized. The effects of drawing temperature and heating time during the fabrication processes are studied.

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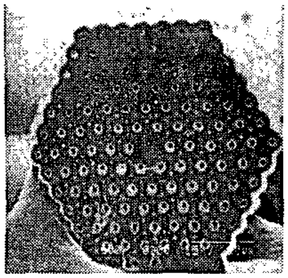
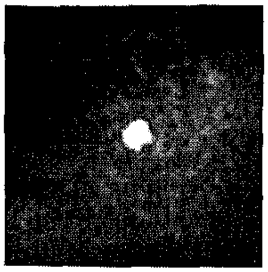
Recently, micro-structured optical polymer fibers (MPOFs) have attracted a lot of attention [1,2]. Compared to silica-based counterparts [3], MPOFs have advantages of better mechanical flexibility and considerable choices of material that can be used. In addition, MPOFs can in principle be fabricated at a much lower cost and novel functionalities can possibly be explored with new materials. In this paper, we report the fabrication and characterization results of single-mode MPOFs over the range from 633 through 1550 nm. The investigation results of the parameters that are critical in the fabrication processes of MPOFs are also discussed.

In fabricating the MPOFs, we used the standard stack-and-draw technique. Hollow PMMA tubes ($n \sim 1.492$) with 4 mm outer diameter and 2 mm inner diameter were first stacked into a hexagonal array. Some hollow tube(s) was/were either replaced with solid rod(s) or removed at selected site(s) in order to form the fiber core. The stacked tubes were annealed at 110 °C for 3 hours for water removal and then heated to form the preform. The drawing of the MPOF is a two-step process. During the first step, the preform was drawn at an elevated temperature into a smaller preform with 40 cm in length and 10 mm in diameter. This smaller preform was then drawn again into a fiber with a diameter between 125 and 300 μm depending on the drawing temperature and speed. Before drawing, the MPOFs preform has to be kept at the drawing temperature for a period of time, called diffusion treatment, in order to achieve uniform temperature distribution across the whole MPOF preform. The drawing speed is controlled under 10 cm/min. From the stacked tubes to a fiber, the overall scale of the structure is reduced by a factor of 300.

The fiber samples we conducted optical measurements were drawn at 175°C, with 1.5-hour diffusion treatment. The combination of these drawing parameters allow us to obtain moderate hole size, while the interstitial holes are almost eliminated. The light source we used to measure the mode pattern is a 1550 nm DFB laser with standard single-mode fiber (SMF) pigtail. We butt-coupled the light from the SMF pigtail into the MPOF sample. The SEM image and the near-field mode pattern of one of the samples are shown in Fig. 1. It can be seen that the light is well-confined and guided in the core. To confirm single-mode guiding, we conducted interference experiment at 1550 nm. Fig. 2 shows the interference pattern between the guided mode and the input laser. The clear interference fringe in Fig. 2 confirms single-mode propagation [4]. The circle in Fig. 2 indicates the position of the guided mode. Similar interference fringe patterns were also observed when a HeNe laser was used for excitation, showing that the single-mode guiding property extends to 633 nm. We also measured the loss of the MPOF samples by the cut-back method. With this method, the loss of the MPOF sample is estimated to be 88dB/m at 1550 nm.



(a) SEM image of the cross-section



(b) Mode pattern

Fig. 1. Measurement results of the MPOF samples.

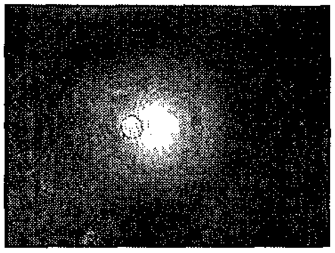


Fig. 2. Interference fringe pattern at 1550 nm.

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