OPTICAL WAVEGUIDE CIRCUITS FABRICATED FROM G-LINE PHOTORESIST

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ABSTRACT

We report on the fabrication of photoresist optical waveguide using FH6400L and BCB. These materials exhibit excellent optical transparency over a wide wavelength range. The waveguide fabrication can be produced using easy and low cost process. The 1×2 MMI coupler is also demonstrated.

INTRODUCTION

Due to the global spread of optical communication, the demand of optical components is gradually increasing. However, many kinds of materials have been considered for optical waveguides, such as polymer [1], silica [2], silicon [3], and $LiNbO_3$ [4]. Among these materials, the polymer attracts a lot of attention because of cost effective and ease of fabrication. The photoresist process is similar to polymer process. In this work, we report using photoresist, FH6400l, as an alternative material for optical waveguide medium.

WAVEGUIDE FABRICATION

The waveguide structure is shown in Fig. 1. The polymer BCB marketed by Dow Chemical was used as cladding layer. The commercial available photoresist, FH6400L, hasing higher refractive index was used as the guiding layer. The BCB was spun onto a clean silicon substrate. In order to form the polymerization of film, the thermal curing was carried out after spin coating. The FH6400L was dispensed and spun at 4500 rpm. After being pre-baked at 90°C for 60 seconds, the sample was subsequently exposed to an appropriate dose of ultraviolet radiation under a conventional Hg arc lamp (g-line) through a photomask. Post-exposure baking was carried at 120°C for 60 seconds. Finally, the waveguides were formed by conventional wet etching.

RESULTS

In order to make sure the waveguides are acceptable, the BCB and FH6400L should be transparent in a wide wavelength range. Fig. 2 shows the transmission spectra of the BCB and FH6400L. They show both of BCB and FH6400L exhibit good transparency. So these materials are acceptable for optical waveguides. In addition, we fabricated the waveguides with refractive index difference between the core and cladding Δn of 0.087 measured at 0.633 μm

The waveguide structure was simulated using the finite difference beam propagation method (FD-BPM). The mode profile shown in Fig. 3 was simulated in 1.2 μm ×1.1 μm waveguide dimension.

Multimode interference (MMI) couplers have found many applications in optical waveguide devices [5]. Fig. 4 shows a schematic diagram of 1×2 MMI coupler. A single mode input waveguide is led to a multimode region with the width of W_{mmi}. Two single mode output waveguides connect at the end of multimode region. The length of MMI region, L_{mmi}, can be calculated by

$$L_{mmi} = \frac{3}{8} L_{\pi} \qquad (1)$$

where L_{π} is the beat length of the two lowest modes.

We also fabricated the 1×2 multimode interference (MMI) power splitter using FH6400L waveguide shown in Fig. 5. The simulated output intensity profile is shown in Fig. 6.

SUMMARY

We have shown that the FH6400L can be used as a material candidate for the optical waveguides. The FH6400L/BCB waveguide structure can be employed over a wide wavelength range. The MMI coupler can be fabricated using this simple and inexpensive process.

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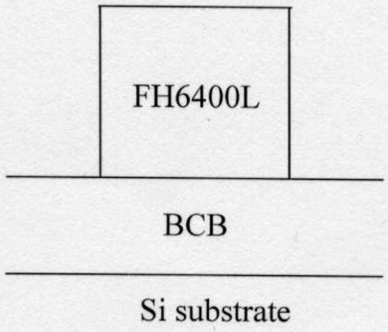


Fig. 1. Schematic cross section of the photoresist waveguide.

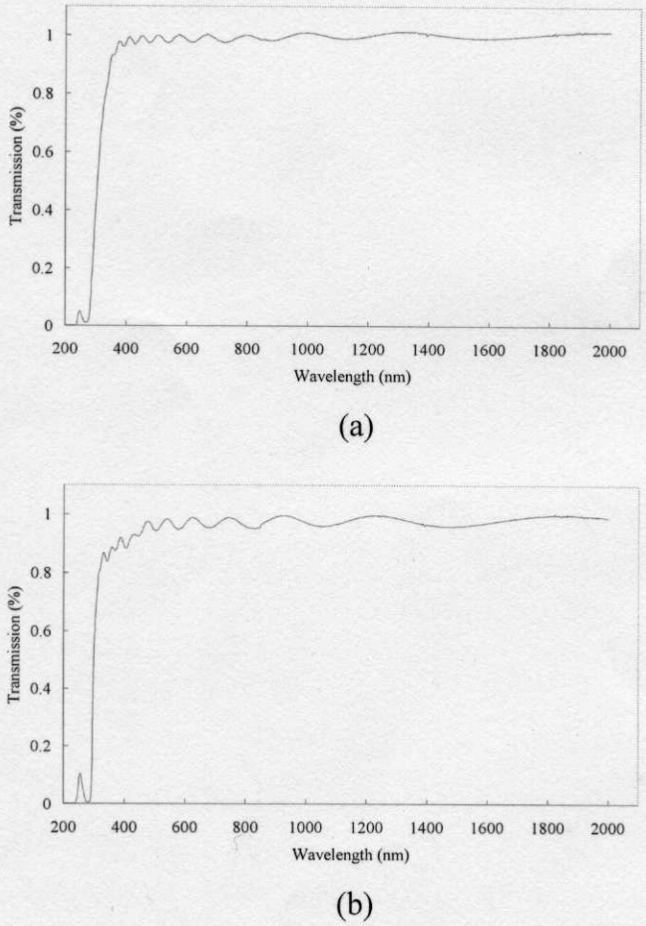


Fig. 2. Transmission spectra of (a) BCB and (b) FH6400L.

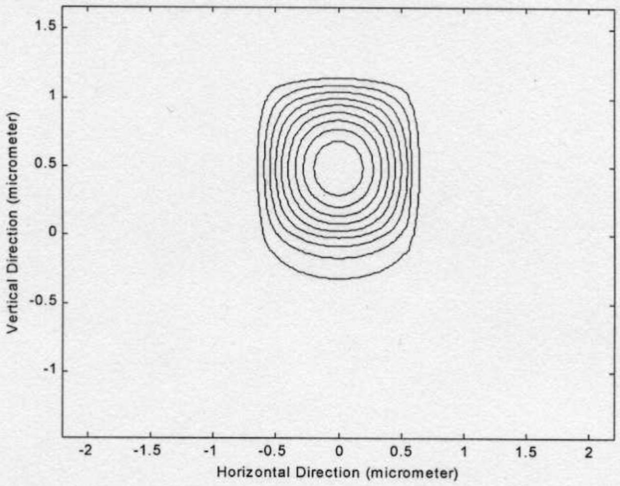


Fig. 3. Simulated mode profile.

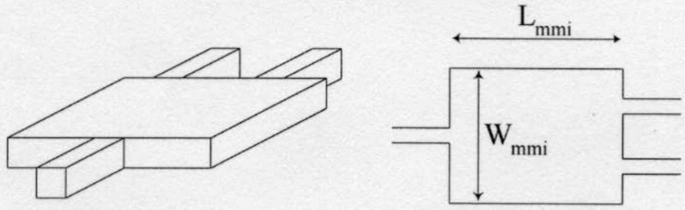
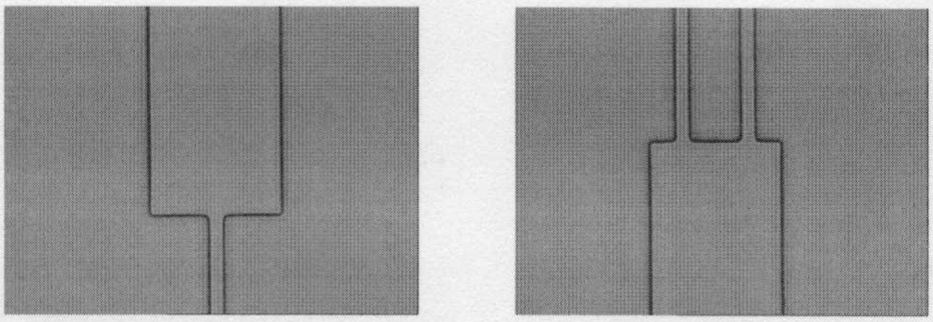


Fig. 4. 1×2 MMI coupler



(a) (b)

Fig. 5. Photographs of (a) input of MMI coupler and (b) outputs of MMI coupler.

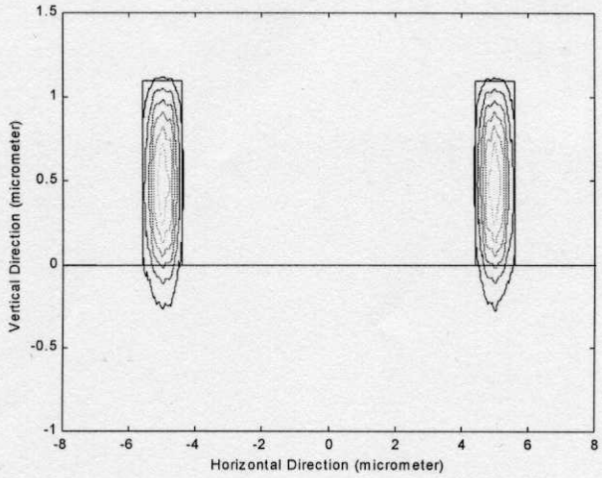


Fig. 6. Output intensity profile of a 1×2 MMI coupler.