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Fluorinated polyimides with high thermal stability and low optical absorption loss have been investigated for waveguide application. Rib-type optical waveguides were fabricated using these fluorinated polyimides.

Keywords: fluorinated polyimides; optical waveguides

INTRODUCTION

Polymeric materials are of great interest for applications in optical telecommunication such as optical waveguides and optical interconnections due to their ease of processing and relatively low cost compared to silica based materials.[1,2] Although these materials have potential advantages for optical applications, there is a need for improvements in some properties such as high thermal property, low thermal stress, and low absorption loss at the optical telecommunication wavelengths of 1.3 and 1.55 μm. Thus, it is reported that fluorinated polyimides are one of potential candidates for real device application

due to its excellent thermal, mechanical, and optical properties.[3,4] In this paper, we describe the synthesis of fluorinated polyimides and their application to optical waveguides

EXPERIMENTAL

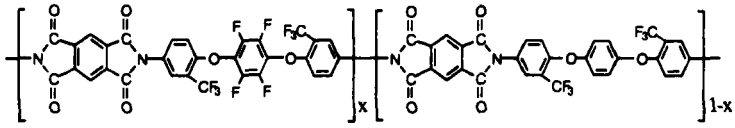

FIGURE 1 Chemical structures of polymers

A series of fluorinated copolyimides were prepared from the two amines, 1,4-bis-(4-amino-2-trifluoromethyl-phenoxy) tetrafluoro-benzene (ATPT) and 1,4-bis-(4-amino-2-trifluoromethyl-phenoxy) benzene (ATPB), with PMDA as shown in Figure 1. The content of ATPT was varied (20~80 mole % based on ATPB). Rib type optical waveguides were fabricated by using conventional photolithography and oxygen plasma etching. The propagation losses of the waveguides were measured by the cut-back method.[5]

RESULTS AND DISCUSSION

The properties of fluorinated polyimides are summarized in Table 1. As shown in this table, theses polymers have T_g around 300 °C and decomposition temperature around 510 °C, demonstrating high thermal stability. Moreover, high fluorine contents of these polymers enable

TABLE 1 Thermal properties of the polymers

Polymer	T_g (°C)[a]	Onset temperature of weight loss (°C)[b]	Fluorine content (wt.%)
PMDA/ATPT	309	522	27.8
PMDA/ATPB	292	537	18.7

[a] determined by DSC at a heating rate of 20 °C/min in a N_2 atmosphere.
[b] determined by TGA at a heating rate of 10 °C/min in a N_2 atmosphere.

them to use as optical polymers for waveguide fabrication due to lower absorption loss of the C-F bond compared with the C-H bond. The refractive indices of polymers were controlled by copolymerization of PMDA/ATPT and PMDA/ATPB as shown in Figure 2. As the amount of PMDA/ATPT (fluorine content) increased, the refractive indices of polymer were decreased due to smaller polarizability of C-F bond compared with that of C-H bond. Rib type optical waveguides were fabricated by using these fluorinated copolymers. An undercladding layer (PMDA/ATPT, n_{TE} = 1.5420, n_{TM} = 1.5211, and 18 μm thick) and a core layer (PMDA/ATPT: PMDA/IATPB = 4:6, n_{TE} = 1.5597, n_{TM} = 1.5397, and 4.4 μm thick) were spin-coated on an oxidized silicon substrate. Core ridges (1.6 μm depth and 6 μm width) were then formed by conventional photolithography and dry etching. Waveguides were fabricated by covering the core ridges with an overcladding polymer (20 μm thick) by spin coating. Figure 3 shows a scanning electron microscopy (SEM) of the core ridge of waveguides. The smooth etch profile could be achieved by this plasma etching process. The propagation loss of the straight waveguides at 1.55 μm was measured by the cut-back method. Less than 0.5 dB/cm of propagation losses were measured in 6 μm width waveguides at 1.55 μm.

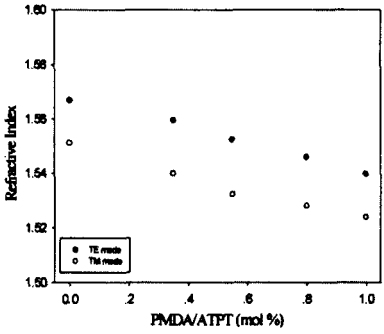

FIGURE 2 Refractive indices of copolyimides

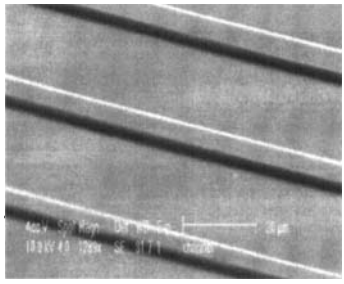

FIGURE 3 SEM image of core ridges

CONCLUSION

The fluorinated polyimides with good thermal stability, refractive index controllability, and low optical loss at the optical telecommunication wavelengths of 1.3 and 1.55 μm were synthesized. Rib-type polymeric waveguides were prepared by using these fluorinated polyimides. These waveguides exhibited low optical loss of less than 0.5 dB/cm at 1.55 μm.

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