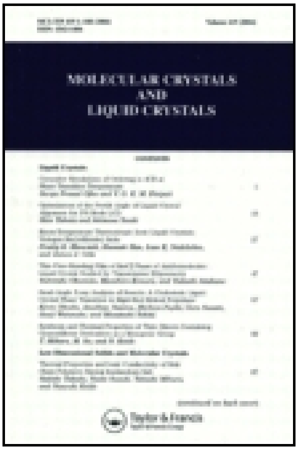

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High Tg Polyarylate Thin Films for Photonic Device Applications

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High *Tg* Polyarylate Thin Films for Photonic Device Applications

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Polyarylates (PARs) with high glass transition temperature (*Tg*) are used for photonic device applications. Optical properties are investigated, and it indicates that the PARs show high thermal stability as well as high optical transparency. Electron-beam lithography can be performed using the PAR thin films, and high resolution surface relief gratings are fabricated by direct electron-beam writing technique together with thermal development.

Keywords: polyarylate; thermal stability; electron-beam lithography; thermal development; surface relief grating

INTRODUCTION

Recently there has been great interest in polymeric thin film waveguides[1] because of their potential application in optoelectronic devices for optical communications. Polymeric system offers many advantages over other systems: ease of processablity, high flexibility, and low cost. However, there are very few reports on heat-resistant polymers[2] sufficient for photonic device applications.

In this study optical properties and thermal stability are investigated with newly synthesized high *Tg* polyarylates (PARs). Moreover, electron-beam (EB) lithography can be performed using the PAR thin films, and high resolution surface relief gratings are fabricated based on this technique.

CHARACTERISTICS OF PARS

Figure 1 shows the chemical structure of the PAR, and Table 1 shows the measured optical properties of each PAR film. Respective *Tg*s of 294 °C and 237 °C were measured in the PAR at m=1,n=0 (BCF) and m=0,n=1 (TMBPA). It indicates that the PARs show high thermal stability as well as high optical transparency. Long-term stability at 100 °C for 100 h and short-term stability at 200 °C for 10 min were also measured in each PARs, and no change in the refractive index or the optical transparency was observed, satisfying the excellent stability.

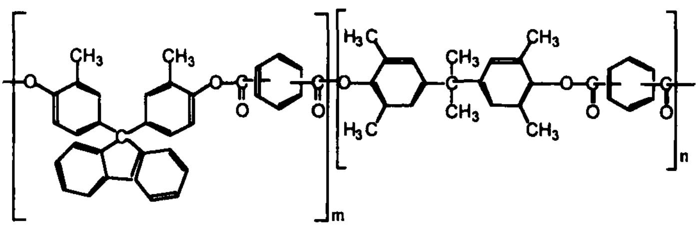

FIGURE 1 Chemical structure of PAR.

TABLE 1 PARs and Optical Properties (*:measured after 200 °C for 10 h)

	m	n	Tg	Trans.(.1 mm^{-1})	n(633 nm)	n(633 nm)*
TMBPA	0	1	237°C	0.91	1.554	1.552
TMBPA/BCF	1	1	262°C	0.90	1.593	1.594
BCF	1	0	294°C	0.89	1.610	1.609

Moreover, unlike polyimide, PARs reveal high solubility to conventional solvents (for example, toluene, tetrahydrofrane and chloroform) and low birefringence (in BCF phase retardation was almost 0 in 0.1 mm thickness).

FABRICATION OF WAVEGUIDE COMPONENTS

In our previous study[3], we reported the characteristics of EB irradiation onto a kind of PAR (U-100) film, and showed that the U-100 film could be thermally developed after EB irradiation. This result motivated us to form the new PAR waveguides with various patterns using direct EB writing technique. Therefore, we attempted to fabricate the high resolutional surface relief gratings (SRGs) in the TMBPA thin film with the thickness of around 1 μm. The grating sample with the designed period of 1.5 μm was fabricated. In this experiment the acceleration voltage was set at 25 kV with the current of 0.5 nA. A beam having a diameter of 70 nm was used. With a support of computer-aided-design (CAD) system the EB was periodically irradiated according to the designed period onto the film with the dose of 2000 $\mu C/cm^2$, then the thermal development at 230 ℃ for 10 min was carried out. Figure 2 shows an atomic force microscopic (AFM) photograph of the fabricated gratings with the actually obtained period of 1.5 μm. After thermal development, SRG was realized with the depth of 200 nm. As shown in the photograph, there is a clear grating pattern without any remarkable defects. BCF film was also found to be developed by EB irradiation with the thermal treatment, thus the high *Tg* PARs act as EB resist (posi-type) as well as low-loss waveguide core.

Furthermore, a channel waveguide was fabricated using conventional lithography and reactive-ion-etching techniques, and the channel ridge with a core size of $8 \times 8\ \mu m^2$ was produced in the BCF film. Detailed characteristics of the channel waveguide based-on these techniques will be reported elsewhere.

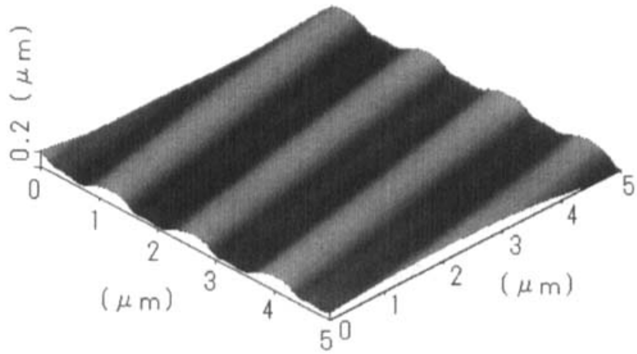

FIGURE 2 AFM photograph of SRG in TMBPA.

CONCLUSION

Optical properties and thermal stability were investigated with newly synthesized high *Tg* PARs, and it indicates that the PARs show high thermal stability as well as high optical transparency. EB lithography can be performed using the PAR thin films, and high resolution SRGs were successfully fabricated. From their excellent characteristics sufficient for optical waveguide fabrication, the PAR films will be candidate for photonic device applications.

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