Extended Abstracts of the 2004 International Conference on Solid State Devices and Materials, Tokyo, 2004, pp. 568-569

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Study of the Novel Polymer COC Waveguide Film

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Abstract

The novel polymer COC waveguide film was fabricated and characterized. The absorption spectrum as well as optical properties of this polymer waveguide was observed by the FTIR and prism coupler technique. The AFM was also used to monitor the morphology of the waveguide film.

1. Introduction

There is currently a great deal of interest in the investigation of optical polymers for optoelectronic and sensor applications [1-2]. Cyclo olefin copolymer (COC) is a new class of polymers; their properties can be tailored during polymerization within a wide range [3]. The COC possesses high transparency, high *T*g (max. 220°C), high water and moisture barrier properties, excellent electric properties (ex: low dielectric constant, low dielectric loss tangent and high dielectric breakdown strength), and good thermal properties [4]. The excellent properties make COC materials potential candidates for optoelectronic applications. In this study, we tried to use this new COC material to make a popular waveguide films. The optic characteristics as well propagation property of the COC guiding film were investigated.

2. Experimental

2.1 Sample preparation

Slab polymer COC waveguides were fabricated on ITO (indium tin oxide) glass substrates by spin coating in a clean room. First, COC (APEL5014) powder was dissolved in toluene solvent. After 24hrs, complete dissolution of COC material was obtained, and then filtered by a filter (0.2 μm) to eliminate any undissolved impurities and dust before use. Five different COC solutions were made up and spin-coated on a well cleaned glass substrate at a rotation speed of between 400 and 1500 rpm. Then the polymer film was cured sufficiently in a vacuum oven. Planar polymer waveguide films with a thickness of between 1.0 μm and 2.0 μm were so obtained in this way.

2.2 Characterization of the COC waveguide film

To determine the optical properties of the polymer film, the spectra between the UV and the Visible range of the polymer films were measured, which covered the 600-1600 nm wavelength range. Simultaneously, the propagation losses and refractive indices of the COC films were measured by the prism coupler technique.

2.3 Poling treatment

The electric field- poling treatment was essential to changes the polymer film into a highly uniaxial medium by molecular alignment [5]. In order to clarify the features of molecular motion in the COC waveguide films under the influence of electric field. Both before and after poling, the optical behaviors and the surface morphology of the polymer film were examined by infrared spectroscopy analysis and AFM techniques in this study. The COC film was poled by applying an electric field of 85 V/μm at room temperature.

3. Results and discussions

The COC waveguide film was found to own high transparency, which was in the vicinity of 92% transmission as wavelength over the communication windows. The refractive index and propagation loss of the COC guiding film was measured by prism-coupler method and demonstrated in Table I. The refractive index and propagation loss of the slab polymer waveguide were found to be a function of the solution concentration for TE and TM-polarized light, and increase with the solution concentration. Therefore, we can tune the optical properties of COC film by properly adjusting the solvent concentration.

COC concentration	3%		4%		5%	
	TE	TM	TE	TM	TE	TM
Refractive index N	1.5193	1.5182	1.5250	1.5213	1.5289	1.5253
Propagation Loss (dB/cm)	0.15	0.32	0.23	0.36	0.30	0.37

Table1. The refractive index and loss of the COC film for different concentration

Since the dipole distribution of the polymer film is a typically random oriented structure, an electric field poling is a necessary procedure to make the dipole reorientation in the polymer film directed towards the poling field [5]. The FTIR spectrum was used to investigate the dipole reorientation of the polymer guiding film before and after applying the electric field. It is well known that this reorientation of the dipoles in the poled polymer film would lead to a change in the intensity of the absorption spectrum. A significant change in the chain conformation was observed by comparing the spectra before and after poling as shown in Fig. 1. We also found that the infrared absorption intensity was increased after poling and annealing, which indicated that the dipole moments of the sample are tend to rearrange to the preferred orientation. We thus concluded that a change in the structure of the COC film took place after the

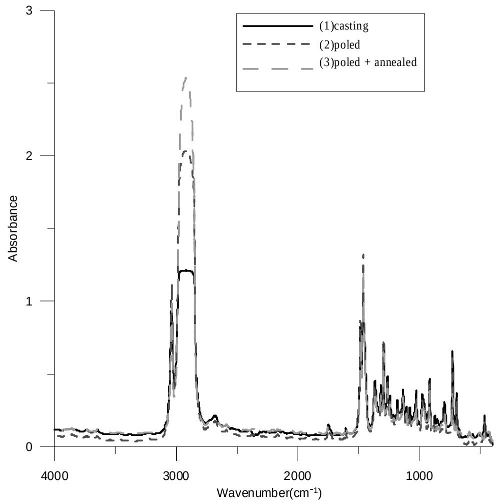
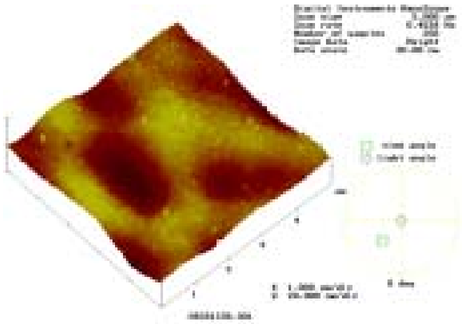
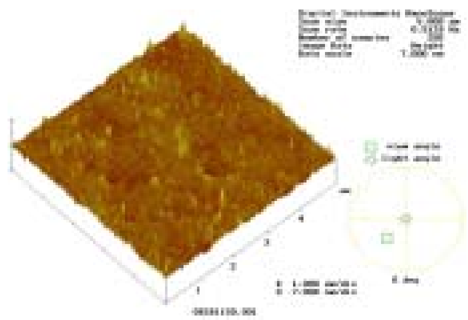


Fig. 1 The FTIR of mCOC waveguide film under some treatments.

poling. Atomic force microscopy (AFM) was also utilized to study the surface morphology of COC films before and after electric voltage applied. The AFM images for the three-dimension view of COC films before and after poling were shown in Fig.2 (a) and (b), respectively. Since the orientation of the molecular dipoles in COC polymer film is typically randomized before poling, the surface roughness of the COC film is higher than that after poling. The surface roughness decreased after poling as a result of the formation of the molecular chains regular arrangement.



(a)



(b)

Fig.2 The AFM images of COC polymer film (a) unpoled (b) poled

4. Conclusions

The COC film possesses high transparency and low propagation loss. The optical properties of the COC waveguide film were dependent on the solution concentration. This modification methodology on the optical characteristics has the potential to manufacture the required COC polymer films of high quality. In addition, the EO behavior could be also formed by high voltage excitation and was assessed by the FTIR and AFM techniques in this study. Therefore these characteristics make the COC material be considered to be most promising for the development of optoelectronic devices. We will expand future applications of the COC materials in the areas of integrated-optic, electro-optical and biosensor applications.

Acknowledgements

We would like to express sincere thanks to the funding of the research by the National Science Council of Taiwan. (NSC 92-2215-E-239-001).

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Appendix

Submitted to area 7

Poster presentation preferred