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OPTICAL PROPERTIES OF POLYMER FILMS FOR NEAR UV RECORDING

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Near UV spectral region is very attractive for different application from microbiology and genetic engineering to optical storage and high-resolution laser lithography. In this sense, the optical investigations in the near UV region are very promising. The most important problems to be solved are the coherent light source and proper recording medium choice. In this investigation we report the results of optical recording in thin polymer films using UV Cu^+ Ne-CuBr acting at the wavelength 248.6, 252.9, 260 and 270.3nm and an excitation pulse repetition frequency of 25kHz. Recording polymer films containing PMMA and trans-stilbene on quartz substrates are created. 1,2-dichlorethan is used as solvent. The film thickness is in the region of 3-10μm. The stilbene concentration relative to PMMA in the solution is varied from 0.125 to 3wt%. The transmission spectra of the obtained films in the region 200-600nm are presented as well as refractive index (RI) measurements in the near UV. The possible application of this holographic recording is discussed.

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1. Introduction

In the last years the high-density information recording was a focusing point of the research in memory materials. Employing optical recording techniques enables both high storage capacity and fast recording and retrieval rates. To a great extent, the performance of such devices is determined by the optical characteristics of the recording media. This has resulted in tremendous efforts in the development of optical storage materials ranging from different crystals to various organic media.

The photophysics and photochemistry of stilbene have been subject of many investigations over the past 45 years. The interest in stilbene is focused on its cis-trans photo-isomerization, which determinate its optical properties. The low cost, good compatibility, allowing integration in different devices, along with the high sensitivity and resolution as well as the high dynamic range [2] have focused attention at thin azobenzene organic films as recording medium. Except in optical storage, these materials find application in optical communications [3,4], nonlinear optics [5] and diffractive optics elements [6].

In the present study, polymer films containing trans-stilbene in polymethyl methacrylate (PMMA) are deposited on quarts substrates and investigated. 1,2-dichlorethan is used as a solvent. The film thickness is 3-10μm. The stilbene concentration relative to PMMA in the samples is varied from 0.125 to 3wt%.

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2. Experimental

2.1. Laser source

An UV copper ion laser is used as an UV light source. The laser operates at five Cu+ lines – 248.6nm, 252.9nm, 259.7nm, 260.0nm and 270.3nm in a nanosecond pulsed longitudinal Ne-CuBr discharge with a pulse repetition rate of 15-25 kHz. The maximal average output power at a multilane output is 1.3W. The average laser power and the peak pulse power on the 248.6 nm laser line are 0.85W and 3.25W, respectively at a laser pulse duration of 10μs. A laser oscillation at two copper atom lines – 510.6nm and 578.2nm, is simultaneously obtained under discharge conditions which are optimized for the UV Cu+ laser oscillation. The total average output power of these two lines is 1.5W, using mirrors for the corresponding spectral area. Using He buffer gas, a laser oscillation on four IR Cu+ lines – 740.4nm, 766.5nm 773.9nm and 780.8nm with a multiline average output power of 450mW is obtained in a nanosecond pulsed longitudinal He-CuBr discharge. The most intensive IR Cu+ line is 780.8nm with an average laser power of 430mW.

Other laser sources are “Spectra Physics” 136 He-Ne laser (632.8nm) and semiconductor laser (790nm).

2.2. Optical characterization

The transmission spectra of the obtained solid films are measured with Carry 5E spectrophotometer in the spectral region 200-600nm. The accuracy of the data is better than 0.5% investigated in [7,8]. The transmission spectra are illustrated in Fig.1.

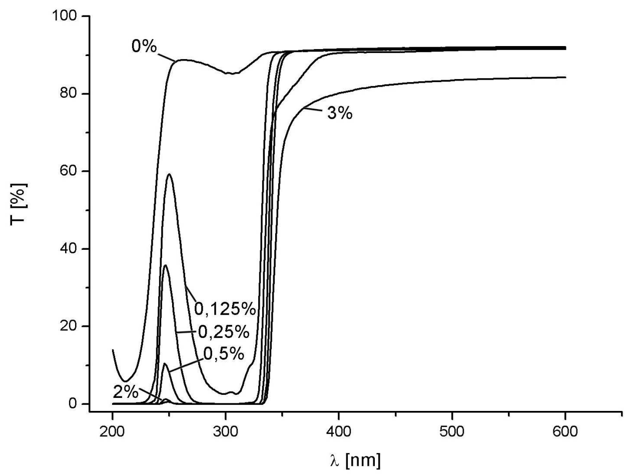

Fig. 1. Transmission spectra of stilbene in PMMA matrix.

We have observed a very interesting fact – the appearance of relatively narrow transmission band between 7-23.5nm. That accidentally coincides with one of the generated UV wavelength of the Cu-Br laser (248.6nm).

The transmission of this UV filter depends on the stilbene concentration, reaching 60% value for 0.125%. The observed dependence is interpolated with exponential decay as shown in Fig.2. The coefficients and the equation are obtained as follows:

$$y = (47.8 \pm 0.6)\exp\left(\frac{-x}{0.313 \pm 0.007}\right) + (0.8 \pm 0.2) \qquad (1)$$

where *x* and *y* are the stilbene concentration and the transmission pick magnitude, respectively.

The full width at half-maximum (FWHM) also depends on the stilbene concentration increasing with its diminishing.

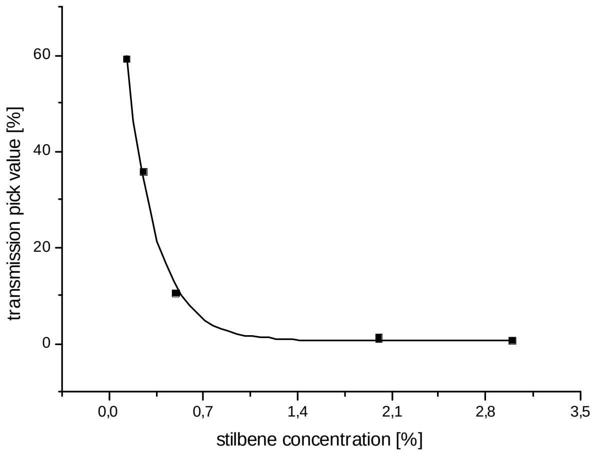

Fig.2. Transmission peak maximum dependence on the stilbene concentration

Refractive index (RI) investigation of the material is performed by the method of the disappearing diffraction pattern (MDDP). This method belongs to the critical angle methods and is appropriate for measuring both liquid samples and solid films. The experimental setup is shown in Fig.3.

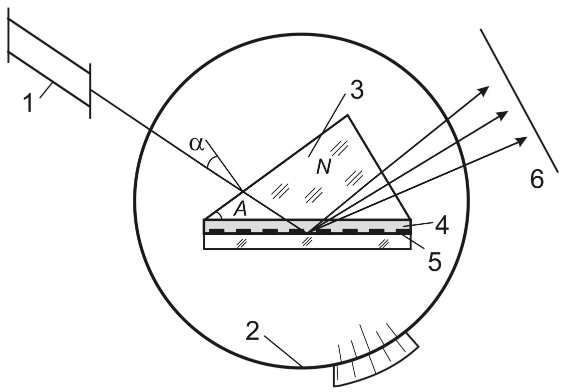

Fig. 3. Experimental setup; 1- laser, 2- rotary table 3- prism, 4- investigated layer, 5- diffraction grating, 6- screen

The diffraction grating (5) is used to indicate the critical angle (α_{cr}) for total internal reflection on the prism (3) and sample layer (4) surface. For small angles of incidence (α) toward the prism-liquid interface, part of the light refracts into the liquid, reaches the grating and diffraction pattern can be observed in reflection. If the angle of incidence is equal or beyond the angle of total internal reflection, the light is totally reflected from the liquid and all diffraction orders disappear on the screen (6). Thus, measuring the angle of incidence (for which the diffraction pattern disappears from the screen) by the rotary table (2) the index *n* is calculated according to:

$$n = N \sin\left(A \pm \arcsin \frac{\sin \alpha_{cr}}{N} \right) \tag{2}$$

where N and A are the RI of the prism and the refracting angle, respectively. The signs "+" and "-" correspond to the clockwise and anti-clockwise laser beam rotation with respect to the normal position to the front prism's face. The measurement error depends mainly on the uncertainty in the determined critical angle [9]:

$$\Delta n = N\cos\left(A + \arcsin\frac{\sin\alpha_{cr}}{N}\right)\left(N^2 - \sin^2\alpha_{cr}\right)^{-1/2}\cos\alpha_{cr}\Delta\alpha_{cr} \quad (3)$$

For small angles $\alpha_{cr} \le 10°$, . For $\Delta\alpha$ ~ 5' and A = 60°, $\Delta n \le \pm 1.10^{-3}$.

The obtained data are presented in Table1. The solid films are measured at 790 and 632.8nm for 2 and 3% stilbene concentration. The liquid phase RI are investigated for a broader spectral region: from 248-790nm.

Table1. Refractive indices of liquid and solid stilbene films at different wavelength.

Stilbene, %	λ, nm phase	790	632.8	578.2	510.6	248.6
2	liquid	1.448	1.453	1.453	1.459	1.462
	solid film	1.479	1.492			
3	liquid	1.450	1.454	1.456	1.459	1.463
	solid film	1.484	1.494			
Refractive index of the prism, N		1.722 TF4	1.735 TF4	1.742 TF4	1.755 TF4	1.508 (fused silica)

3. Conclusion

The optical properties and holographic recording possibilities in polymer films in near UV spectrum were evidenced.

Acknowledgements

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