PC assisted waveplates application for one step holographic direct surface relief patterning on azopolymer film

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Abstract - Photosensitive film of polyvinyl alcohol: Metil Red (PVA: Methyl Red) was obtained. Method of polarized holographic recording for one step direct surface relief patterning on the azopolymer film was applied. Superimposed diffraction gratings were simulated by PC. The correlation of parameters of simulated superimposed gratings patterns with those recorded was demonstrated by interferometric microscopy measurements.

***keywords*—Azopolymer, holographic recording, diffraction grating , polarized recording, computer simulation.**

I. INTRODUCION

The holography and laser invention have led to the development of powerful tools with applications in metrology, data storage, materials engineering [1].

One way of obtaining a diffraction grating patterns is holographic recording. A holographic diffraction grating can be produced with equally spaced grooves by using intersecting light beams as the recording sources. The interference pattern between two coherent wavefronts is recorded in a photosensitive media. The method creates amplitude modulation of pattern which reproduces it on media [2].

Pointed method as a rule needed additional wet development of media for relief patterning. Polarized holographic recording method can creates directly surface relief on some photosensitive media. For example, it can be done in chalcogenide glasses or photosensitive polymers [3]. Advantage of these media are high spatial resolution and a lot of compositions. The purpose of the work is holographic recording assisted PC waveplates for one step direct surface relief patterning on the photosensitive azopolymer film.

II. MATERIALS AND METHODS

As a holographic recording media a photosensitive film of polyvinyl alcohol: Metil Red (PVA: Methyl Red) was synthesized. The azopolymer was obtained at the reaction of esterification of polyvinyl alcohol (PVA) with Methyl Red in reflux at 65 ° C for 120 minutes (Fig. 1).

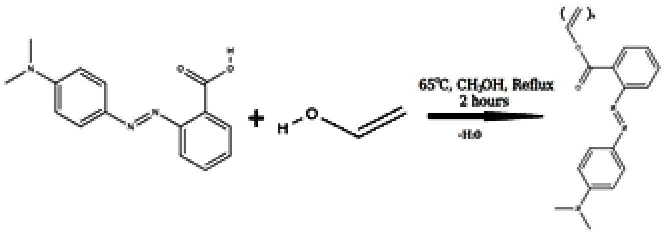


Fig. 1 Scheme of synthesis and chemical structure of PVA: Methyl Red synthesis is presented.

In our study the obtained homogeneous azopolymer solution was deposited on a glass transparent substrate by the spin-coating method at angular velocity of 100 RPM for uniform coating of substrate. The programmable spin-coater "SGS Spin-Coat G3P-8" was used. The thickness of the azopolymer film and grating topography was studied at the modified interferometric microscope MII-4 supplied with digital camera for interferogram acquisition [4]. An interferometer magnification 490^x was set. Acquired microscopic interferograms have been processed by PC to extract surface information. The mean thickness value of the azopolymer layer was estimated as 300 μm.

Method of polarized holographic recording for one step direct surface relief patterning on the azopolymer film was applied. The diffraction grating was recorded by using laser interferometer with possibility to set a number of polarization configurations (Fig. 2). Interfering beams with S-S, RCP: LCP or (+45º)–(– 45º) polarization configurations can use for gratings recording. Waveplates in interferometer beams produce such configurations. The gratings were recorded at the RCP: LCP polarization, obtained with computerized LC waveplates with HOLOSTEP v1.0 software. Such beams configurations not create amplitude modulation but only phase one. To obtain pointed above circular polarizations, the waveplates were rotated around the fast axis by computerized motorized system and set at angles of ±45 °, with 0.9^0 accuracy. Real-time control of diffraction efficiency by photo detector in first order of diffraction was done.

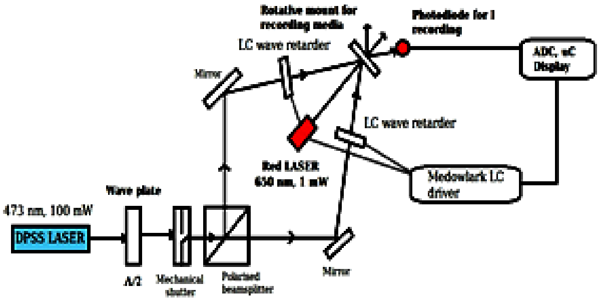
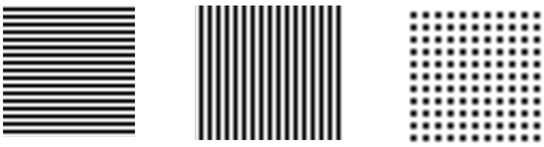


Fig. 2 Optical setup of polarizing holographic recording of diffraction gratings and pattern obtaining.

Mathematical modelling of 2 superimposing diffraction patterns was performed in MATLAB by summing two perpendicular diffraction gratings for the analysis of the diffraction pattern formation. This simulation allowed the modification of the hologram recording parameters, the angle of incidence of the beams, grating period, the wavelength and the intensity of each beam. Pattern of both grating with the spatial frequencies of 200 lines/mm was modelling and recorded. The recording steps of the proposed pattern recording were shown in Fig. 3.



a) b) c)

Fig. 3 The holographic recording steps, where the proposed structure (c) is obtained by superimposing two mutually perpendicular gratings (a, b).

The diffraction patterns were recorded in two successive steps. In the first step, the first grating is recorded, where the exposure time is 0.5s. The second step consists of the substrate rotation on the angle of 90^o and exposure for 1s for recording, with intensity 1500 mW/cm^2 and doze 1.5 J/cm^2. A superimposed grating pattern as a result of recording the two crossed gratings was obtained.

III. Results And Discussion

The RCP and LCP polarizations of 2 beams were obtained by pivot on the LC waveplates, relative to the fast axis at ±45^0. The obtained diffraction pattern was rotated to 90^0 and a recording process was repeated. Consequently, the first order of diffraction was observed during the recording of the second grating (Fig. 4).

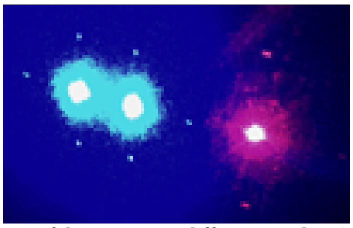


Fig. 4 The occurrence of the criss-cross diffraction orders (small white points) with a rotation of 90^0 of the 1st diffraction grating (figure-of-eight on the left) and diffraction maximums of the pilot beam (on the right).

Using microscope, the depth of the first grating relief (Fig. 5) was measured and the value is estimated as 162 nm. The grating periods were measured too.

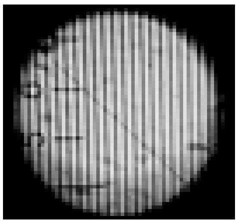
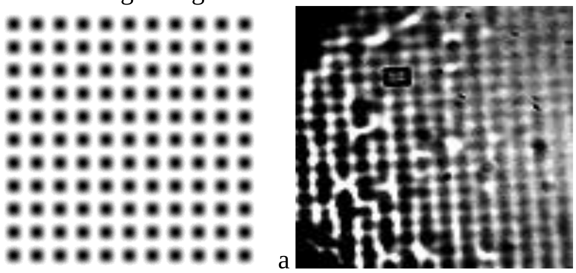


Fig. 5 Image of obtained by microscope MII-4 of the first diffraction grating is shown.

It was found values of periods of recording and simulated patterns are in good agreement.



a b

Fig. 6 Simulated superimposed diffraction pattern in MATLAB (a), diffraction pattern recorded on an azo-polymer film PVA: MethylRed (b) are presented.

IV. Conclusions

The synthesized polymer PVA: Methyl Red has been studied in form of thin film. Method of polarized holographic recording for one step direct surface relief patterning on the azopolymer film was applied. LC waveplates were used for the gratings recording in RCP:LCP polarizations configurations. Parameters of recorded diffraction gratings were compared to the gratings simulated in MATLAB. It has showed a good correlation, indicating the correctness of the simulation. Superimposed grating analysis with the MII-4 interferometric microscope demonstrated that the pattern relief is 162 nm. It has been shown polymer to be useful as a recording medium for superimposed gratings.

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