UDC 681.7:520
DOI: 10.20535/2077-7264.2(76).2022.265687

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DIGITAL ALGORITHMS POLARIZATION-HOLOGRAPHIC 3D LAYERED MAPPING OF MICROSCOPIC IMAGES OF POLYMERE FILMS IN POLYGRAPHIC PRODUCTION

Scientific work presents systematized data of original experimental research of diagnostic efficiency of multiparametric (using polarizing mathematical fourth order — Stokes vector) layer-by-layer three-dimensional laser Stokes-polarimetric coordinate digital mapping of a series of microscopic polarization-filtered images of coordinate distributions of random values of parameters of azimuth (the plane angle of oscillation of the laser electric intensity vector) and ellipticity (eccentricity of the laser coherent electric intensity vector trajectory) of a set of optically anisotropic diffuse samples, in which multiple interaction of laser radiation and optical inhomogeneities takes place.

Keywords: polarimetry; 3D mapping; diagnostics; depolarization layers of optically anisotropic polyethylene films.

Introduction

Traditionally, laser polarimetry methods have been used to study optical manifestations of polycrystalline component of phase-inhomogeneous layers with different architectonics [1–5].

The main information result of polarimetric studies is the information about the structure of the object in the form of polarisation maps of the azimuth and ellipticity of the polarization of its microscopic image [6–10].

This method works well under conditions of single scattering of laser radiation in the volume of polycrystalline layer.

At the same time real polymer layers used in polygraphy are diffuse or multiple scattering.

Therefore, the development of new polarimetric methods is relevant for them.

In our work we will explore the possibilities of 3D Stokes polarimetry method based on digital holographic reconstruction of layer-by-

ISSN 2077-7264. Технологія і техніка друкарства. 2022. № 2(76)

layer azimuth and ellipticity polarization maps of microscopic images of polymer layers.

Methods

The optical location of the method of polarization interferometry of microscopic images of diffuse polycrystalline polyethylene films from control group 1 and research group 2 is illustrated in fig. 1 [1–7].

The optical system of microobjectives *2* forms a flat wavefront of coherent radiation of a gas He-Ne laser one.

Optical cube *3* acts as a beam splitter and forms two beams — illuminating and reference or reference.

Inverting mirror *4* directs the laser beam through a polarizing filter system *6–8* in the direction of the polyethylene sample *9*. The digital microscopic image of the object *9* is projected by the polarizing microlens *10* onto the plane of the digital camera *15*.

The ‘reference’ laser beam is directed by the optical mirror *5* through the polarizing filter *11–13* into the digital image plane of the object *9*.

The resulting laser interference pattern is recorded by a digital camera *15* through a linear polarizer *14*.

We use the well-known algrithm for determining the distributions of the Stokes vector $S_{i=1;2;3;4}(\theta_k,x,y)$ parameters with algorithmic reproduction of the polarization azimuth maps $\alpha(\theta_k,x,y)$ in each phase plane θ_k [8–10]

$$\alpha(\theta_k,x,y)= \\ =0,5\operatorname{arctg}\left[\frac{S_3(\theta_k,x,y)}{S_2(\theta_k,x,y)}\right]. \quad (1)$$

To determine the diagnostic-optimal phase plane, we used the following algorithm for analyzing layer-by-layer polarization maps.

1. The step of discrete phase ‘macro’ scanning was chosen $\Delta\theta_k^{max}=0.25rad$.

2. Algorithmically, a series of polarization azimuths corresponding to each $\Delta\theta_k^{max}=0.25rad$ of the layer-by-layer coordinate distributions was reconstructed.

3. Statistical moments of the 1st–4th orders $SM_{i=1;2;3;4}$ were calculated, which characterize the obtained 2D distributions of the polarization azimuth and elliptisity.

Results

Coordinate (fragments (1)) and statistical parameters of histograms (fragments (2)) of the distributions of the polarization azimuth of digital microscopic images are shown in a series of fragments in fig. 2–5.

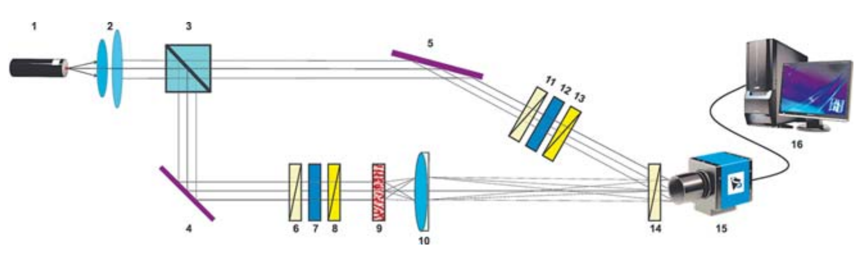

Fig. 1. Optical scheme of 3D Stokes-polarimetry of microscopic images of polymer layers from group 1 and group 2

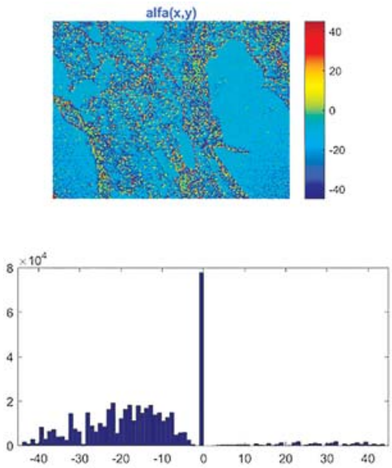

Fig. 2. Topographic map (fragment (1)) and histogram of layer-by-layer distribution (fragment (2)) of the polarization azimuth of a digital microscopic image of a control group 1

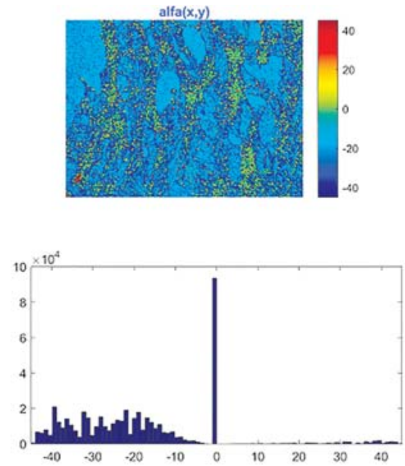

Fig. 3. Topographic map (fragment (1)) and histogram of layer-by-layer distribution (fragment (2)) of the polarization azimuth of a digital microscopic image of a research group 2

Discussion

Comparative analysis of the results of layer-by-layer polarization-holographic measurement of polarization maps (fig. 2–5) of microscopic images of diffuse polymer layers from group 1 and group 2:

— The presence of the widest possible range of coordinate and quantitative changes in the polar-

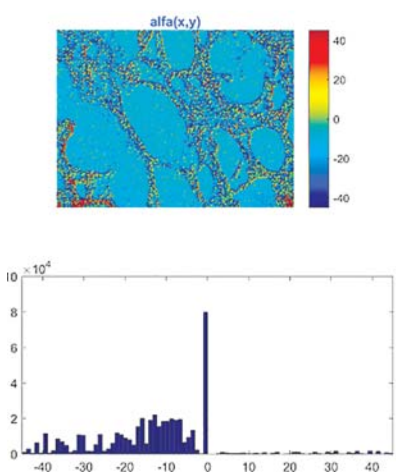

Fig. 4. Topographic map (fragment (1)) and histogram of layer-by-layer distribution (fragment (2)) of the polarization elliptisity of a digital microscopic image of a group 1

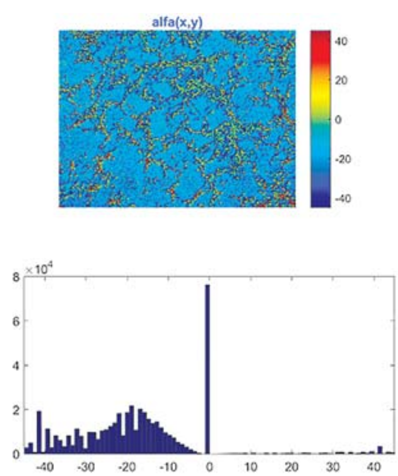

Fig. 5. Topographic map (fragment (1)) and histogram of layer-by-layer distribution (fragment (2)) of the polarization elliptisity of a digital microscopic image of a group 2

ISSN 2077-7264. Технологія і техніка друкарства. 2022. № 2(76)

ISSN 2077-7264. Технологія і техніка друкарства. 2022. № 2(76)

ization azimuth value in the optimal phase plane of digital microscopic images — ($-0.25\pi \le \alpha \le 0.25\pi$).

— Individual structure of histograms of distributions of the polarization azimuth in the optimal phase plane of digital microscopic images of a set of diffuse polymer layers from group 1 and group 2.

The following results were obtained an excellent level of accuracy of differential of diffuse polymer layers from group 1 and group 2 — A_C = 95 % ÷ 96 %.

Conclusions

Possibilities of 3D Stokes-polarimetric mapping of microscopic images of diffuse polymer layers from group 1 and group 2 of layered polarization azimuth maps.

System 3D polarization-holographic measurements and statistical analysis of algorithmically reproducible layer-by-layer maps and histograms of the distribution of the azimuth of polarization of microscopic images of representative samples of polymer films were carried out.

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В роботі представлено систематизовані дані оригінальних експериментальних досліджень діагностичної ефективності багатопараметричного (з використанням поляризаційного математичного четвертого порядку — вектора Стокса) пошарового тривимірного лазерного стоксово-поляриметричного цифрового відображення серії мікроскопічних зображень із поляризаційним фільтром, координатних розподілів випадкових значень параметрів азимута (плоского кута коливань вектору електричної напруженості лазера) та еліптичності (ексцентриситету траєкторії когерентного вектору електричної напруженості лазера) набору оптично анізотропних дифузних зразків, в яких множинна взаємодія, має місце лазерне випромінювання та оптичні неоднорідності.

Ключові слова: поляриметрія; 3D мапінг; діагностика; деполяризаційні шари оптично анізотропних поліетиленових плівок.

Надійшла до редакції 17.09.22