Introduction
Among most methods for polarization studies of phase-inhomogeneous layers of different origin, analytical approaches, which are based on the optical-thin-layer approximation, predominate. This approximation assumes a predominantly single scattering of laser radiation in the volume of the phase-inhomogeneous layer. In such a situation, there is an unambiguous diagnostic relationship between the polarization parameters of the object field and the optical anisotropy maps. However, this approximation is very rarely realized in real diagnostic practice using polarized laser radiation.

Most polymer objects are partially depolarizing. Therefore, it is urgent to further develop and generalize the methods of MMP of the polycrystalline structure of polymer layers with different light scattering multiplicity, or different depolarizing ability [1–5].

This work is aimed at investigating the possibilities of differentiating changes in the optical anisotropy of methyl acrylate layers from group 1 and group 2.

Methods
The optical measurement scheme is shown in fig. 1 [6–8].
Samples 6 were irradiated with a parallel ($\varnothing = 2 \cdot 10^3 \mu m$) low-inten-
A polarizing feed consisting of 3 quarter-wave plates, (Achromatic True Zero-Order Waveplate) and 4 polarizer (B+W Kaesemann XS-Pro Polarizer MRC Nano).

Polymer layer 6 was sequentially probed with a laser beam with the following types of polarization: linear with azimuths of 0°, 90°, +45° and right circulation (⊗).

Polarized images of the polymer layer using polarizing micro-lens 7 (Nikon CFI Achromat P, focal length — 30 mm, numerical aperture — 0.1, magnification — 4×) were projected into the plane of the photosensitive area (mxn = 1280x960 pixels) of the CCD camera 10 (The Imaging Source DMK 41AU02.AS, monochrome 1/2 “CCD, Sony ICX205AL (progressive scan) resolution — 1280x960, size of the photosensitive area — 7600x6200 μm; sensitivity — 0.05 lx; dynamic range — 8 bit, SNR — 9 bit).

Image analysis of polymer layers 6 was carried out using a polarizer 9 and a quarter-wave plate 8.

The calculations within each pixel of the digital camera 10 of the set of elements of the Mueller matrix $M_{ik}$ of the sample of the polymer layer were carried out in accordance with the algorithm [9, 10]

$$
M_{11} = 0.5(V_1^0 + V_1^{02});
M_{12} = 0.5(V_1^0 - V_1^{02});
M_{13} = V_1^{45} - M_{11};
M_{14} = V_1^{45} - M_{13};
M_{21} = 0.5(V_2^0 + V_2^{02});
M_{22} = 0.5(V_2^0 - V_2^{02});
M_{23} = V_2^{45} - M_{21};
M_{24} = V_2^{45} - M_{23};
M_{31} = 0.5(V_3^0 + V_3^{02});
M_{32} = 0.5(V_3^0 - V_3^{02});
M_{33} = V_3^{45} - M_{31};
M_{34} = V_3^{45} - M_{33};
M_{41} = 0.5(V_4^0 + V_4^{02});
M_{42} = 0.5(V_4^0 - V_4^{02});
M_{43} = V_4^{45} - M_{41};
M_{44} = V_4^{45} - M_{43};
$$

Here $V_{i=2,3,4}^{0.45;90;⊗}$ — parameters of the Stokes vector of points of a

Fig 1. Optical scheme of the polarimeter, where 1 — He-Ne laser; 2 — collimator; 3 — stationary quarter-wave plate; 5, 8 — mechanically movable quarter-wave plates; 4, 9 — polarizer and analyzer; 6 — polymer layer; 7 — polarizing micro-lens; 10 — CCD camera; 11 — personal computer
digital image of a polymer layer sample measured for a series of linearly (0°; 45°; 90°) and right-circularly (⊗) polarized laser beams

Here \( I_{0;45;90;135;⊕;⊗} \) — the intensity of the light transmitted by the object, passed through the linear polarizer 9 with the angle \( Θ \) of rotation of the transmission plane: 0°; 45°; 90°; 135°, as well as through the «quarter-wave plate—polarizer» system of the polarization analysis block, which transmits the right- (⊗) and left- (⊕) circularly polarized components of the object laser radiation.

Expression for calculating the elements of a differential matrix of the 1st order [3, 4].

\[
\begin{pmatrix}
V_{1}^{0;45;90;⊗;⊕} & V_{2}^{0;45;90;⊗;⊕} & V_{3}^{0;45;90;⊗;⊕} & V_{4}^{0;45;90;⊗;⊕} & V_{5}^{0;45;90;⊗;⊕} & V_{6}^{0;45;90;⊗;⊕} & V_{7}^{0;45;90;⊗;⊕} & V_{8}^{0;45;90;⊗;⊕}
\end{pmatrix}
\]

Results

The results of studying the capabilities of the method of differential Mueller-matrix mapping of the completely polarized polycrystalline component of optically thick (attenuation coefficient \( τ = 0,83÷0,91 \)) layers of methyl acrylate from group 1 (31 samples) and group 2 (31 samples) are presented.

In fig. 2 and fig. 3 shows a series of histograms of the distributions of the averaged parameters of linear and circular birefringence (LB; CB; LB’ — fig. 2) and dichroism (LD; CD; LD’ — fig. 3) of methyl acrylate layers from group 1 (fig. 2, fig. 3, fragments (1)–(3)) and group 2 (fig. 2, fig. 3, fragments (4)–(6)).

Discussion

The quantitative transformations of the polycrystalline structure of optically thick layers of methyl acrylate are illustrated by the data of the statistical analysis of two-dimensional distributions of the magnitude of the elements.
Fig. 3. Histograms of the distribution of the linear (fragments (1), (3), (4)) and circular (fragments (2), (5)) dichroism of methyl acrylate layers from group 1 (fragments (1)–(3)) and group 2 (fragments (4)–(6))

of the first-order differential matrix of the fully polarized component of the depolarizing polycrystalline networks.

Table 1 and Table 2 show the average values and average errors of the statistical ($Z_{i=1;2;3;4}$) parameters characterizing the distributions of the values \(\langle m_{\times} \rangle\) of the methyl acrylate layers of both groups.

Comparative analysis of the aggregate of statistical moments of the 1st–4th orders revealed the following ones that are most sensitive to changes in the phase and amplitude anisotropy of methyl acrylate layers from group 1 and group 2 against the background of a depolarized background of multiply scattered radiation (highlighted in gray):

\[
\Delta Z_3 (LB, CB, LB') = 2,42 \div 2.83 \quad (Ac = 91%);
\Delta Z_4 (LB, CB, LB') = 2,15 \div 5.97 \quad (Ac = 94%);
\]

Table 1

<table>
<thead>
<tr>
<th>(Z_i)</th>
<th>(\langle m_{23,32} \rangle)</th>
<th>(\langle m_{34,42} \rangle)</th>
<th>(\langle m_{34,41} \rangle)</th>
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<tbody>
<tr>
<td>(Z_1)</td>
<td>5,75±0,33</td>
<td>8,16±0,57</td>
<td>3,27±0,16</td>
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<tr>
<td>(Z_2)</td>
<td>4,23±0,28</td>
<td>2,87±0,16</td>
<td>1,93±0,12</td>
</tr>
<tr>
<td>(Z_3)</td>
<td>0,62±0,036</td>
<td>1,69±0,11</td>
<td>2,12±0,13</td>
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<tr>
<td>(Z_4)</td>
<td>0,41±0,028</td>
<td>0,88±0,054</td>
<td>1,96±0,13</td>
</tr>
</tbody>
</table>
Conclusions

1. A method of differential Mueller-matrix mapping is proposed and substantiated for reproducing the distributions of the parameters of linear and circular birefringence and dichroism of partially depolarizing methyl acrylate layers from group 1 and group 2.

2. Achieved good and excellent diagnostic quality by the method of differential Mueller-matrix mapping of partially depolarizing methyl acrylate layers from group 1 and group 2.

Table 2

| Z_i  | \langle|m_{22,21}\rangle | \langle|m_{33,31}\rangle | \langle|m_{44,41}\rangle |
|------|--------------------------|--------------------------|--------------------------|
| Z_1  | 5.29±0.33                | 6.13±0.39                | 5.85±0.37                |
| Z_2  | 4.74±0.27                | 3.36±0.18                | 2.72±0.15                |
| Z_3  | 0.66±0.038               | 0.87±0.052               | 0.74±0.043               |
| Z_4  | 0.43±0.027               | 0.51±0.031               | 0.44±0.029               |

References


Метою роботи є узагальнення методів лазерної поляриметрії на випадок частково деполяризуючих оптично анізотропних полімерних шарів.

Ключові слова: поляризація; оптична анізотропія; метилакрилати; контроль температури.

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