OPTICAL PROPERTIES OF PLASTIC SHEET WITH EMBEDDED VOLUMETRIC LASER ENCODING

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It is important to improve methods for laser-marking and identification of physical objects. Earlier the volumetric laser marking of objects was developed [1]. The practical results and samples created with the different methods and approaches for volumetric laser marking and recording of digital information require rigorous analysis and interpretation. For successful accomplishment of this at ask an appropriate experimental protocol in corporation ad equation section methods and measurement techniques are essential.

Wepresentexperimentalmeasurementresultsobtainedbymultiple-angle-of-incidence,single-wavelengthellipsometry,employedforinspectionofa transparent flat 2mm thick plastic sheet sample with mbedded volumetric lase rencoding.

Themarkinglayerwasformedinthebulkofthesamplebyrecordingapatternofenergylevels(J=7µJ,J=14µJ, andJ=22µJ)wereestablishedfortheindividuallaserpulsesandeachpairofmarkswascreatedbydouble-pulselaserirradiation. The optical polarization parameters of the examined sample were evaluated using a laser ellipsometer with light wave length λ=632 нм. The ellipsometric parameters as the phase shift Δ between the p-ands-components of the polarization vector and the azimuth Ψ of the restored linear polarization were obtained as dependencies on the light incidence angle φ (Figure1).

The angular dependencies Δ(φ) and Ψ(φ) are plotted in Figure1 for a range of angular values bracketing the Brewster's angle (φB = 57.7° as defined at Δ=90°) denoted by vertical dashed lines. The value of φ B turns out to be practically the same for the unmarked area (curve1) and for the are a marked by laser pulses with energy of J= 22 µJ (curve2). The position of the minimum of Ψ(φ) (Figure1(b) ,curve2) is slightlyraised and shifted to the rightof the Brewster's angle (dashed line) that is, to ward higher angles.

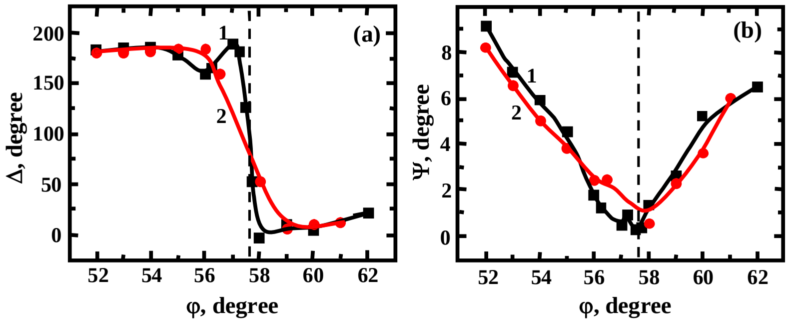

Figure 1: Angular dependences of the ellipsometric parameters Δ(a) and Ψ(b) for the unmarked (initial) area of the plastic sheet (curve 1) and for the area with laser-induced marks (curve 2).Horizontal positions of the dashed vertical lines correspond to the value of Brewster's angle.

Observed in variability of Band only negligible changes in the angular dependence of Ψ constitute strong evidence that the laser-induced formation of small marks conducted within the scope of our experiment caused no significant global disturbance in respect to the total encoded area. The formation of local damages pots in a plastic sheet by employing laser pulses with different energies does not, therefore, change the state of the plastic matrix.

For characterization of the marked layer, a special slope phase field parameter $\delta\varphi s$ can be used. The slope phase field is the range of light incidence angles φ (at the abscissa axis) with in which the phase shift Δs harply changes from 180° to 0°. In our case, $\delta\varphi s$ is analyzed where cosΔ sharply in creases' . e. from -0.9 to 0.9 (Figure 1(a)). As seen, the slope phase field value for the marked area irradiated with J=22μJ (curve2) is larger than the $\delta\varphi s$ for the unmarked area (curve1). The $\delta\varphi s$ parameter can be employed for estimating average sizes and surface densities of laser-induced marks in encoding layers created in other experimental setup sand with different methods.

Keywords: volumetric laser encoding, ellipsometry, Brewster'sangle

1. K.Kanev, V. Mizeikis, V. Gnatyuk. Localization encoding in the bulk of physical objects by laser-induced damage // Proceed. of the Joint Int. Conf. on Human-Centered Computer Environments, (8-13 Mar. 2012, Aizu-Wakamatsu ,Japan), 93-98 (2012).