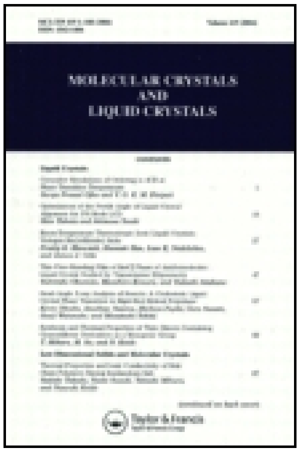

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Optical Properties of Organic Films for Compact Disk

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Optical Properties of Organic Films for Compact Disk

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The optical properties in the middle infrared of pyrosolyn-based films on glass and silicon substrates were investigated by spectroellipsometric method realised in the Beattie-Conn scheme using Fourier transformation spectrometer. These thin dye films are found to be rather anisotropic due to perceptible singularity in ellipsometric parameter spectra at the wave number of 1250 cm^{-1} and its red-shifted distinct fine structure. The behaviour of this singularity being registered by the film-substrate and substrate-film side probing is shown to depend on such technological parameters as a distance between a vaporiser and a substrate, the temperature of a glass substrate and the pressure of vapour of volatile components of dyes. The estimation of the thickness d of the dye films formed on a glass substrate by solution of inverse ellipsometric task is efficient at d~100 nm. The recording surface structure acquired by using the second harmonic radiation of Nd-laser at its power of the order of 10 mWt during recording in a pit form was investigated by means of scanning tunnel microscopy.

Keywords: Dye film, information recording, spectroscopic ellipsometry, scanning tunnel microscopy.

INTRODUCTION

Thin dye films are a novel material for different applications in optoelectronics and optical information recording both write once, read many and reversible. These films can be used as a master disk for CD-R replication because a pit shape fit all the requirements which are in need for high density compact discs.

Along the formation of CD-mastering on the photoresistive and photosensitive layers for such aims the polymeric layers of organic dyes are also applied. Owing to information recorded on the layers containing organic dyes, a number of such technological operations as the development of a photoresistive layer, its duplication, and drying disappeared and as a result the reliability of CD-mastering due to the use of information recording on polymer dye layer increased. That is why the main aim of this work comprises the selection of such kind of dyes on a base of a pyrosolyn due to their appropriate optical properties in recording-reading processes.

EXPERIMENTAL

Three kinds of dyes were used for preparating organic films namely so-called bright-red (BR), orange-red (OR) and bright-orange (BO, this dye possesses additional Si-C-H bonds in comparison with two previous ones) dyes were investigated. These dyes are manufactured from pyrosolyn (pyrosolan) and differ from each other due to a spectral position of their main luminescent band within the orange-red range. The dye films were deposited in vacuum by thermal sputtering of organic material on both glass and silicon substrates. Each performance of specimens has been based on certain regulations of depository regimes and obligate accompaniment of technology processing by formation of control witness sample (WS), disposed from a vaporiser at the distance of the order of 40 cm.

To study the fundamental properties of optical absorption in these organic dyes outside the mentioned range, the infrared spectroellipsometric measurements using a Fourier-transform spectrometer in the middle infrared range (400-5000cm^{-1}) in accordance with the scheme of polarimetric Beattie-Conn method were carried out [1]. The intensities of light reflected from both film-substrate (FS) and substrate-film (SF) systems at the fixed azimuth of a polariser $\Psi p=45^0$ and four standard azimuths of an analyser were measured to obtain the ellipsometrical parameters Δ (Δ is the phase shift between s- and p-components of polarisation vector of light beam) and tgψ (ψ is the azimuth of a restored linear polarisation of light beam reflected) [2].

Experimentally the tasks were formulated as following:

- to what degree such technological parameter as a distance D between a vaporiser and a glass substrate influences the optical characteristics of BR dye film with its thickness d estimated as great as about 120nm at $D=D_1=10\div15$cm after displacement to $D=D_2=40$cm (this disposal is corresponding to WS preparing) (task 1);

-what difference is between the optical characteristics of BO dye films on glass substrate ($d\approx85\div95$nm at D_1) and silicon substrate ($d\approx120$nm at D_1) (task 2);

-what differences are between the optical characteristics of BO dye film ($d\approx75$nm at D_1, refraction index $n\approx1,5\div1,7$ in the visible) on chromium film, previously deposited on a glass substrate at Cr heating temperature $T\geq1000^0$C as compared with solely Cr film on such glass substrate (task3);

-what differences are between the optical characteristics of OR dye film on a glass substrate and a silicon substrate at $D_2=40$cm (task 4);

-to what degree are optical characteristics of OR dye film ($d\approx120$nm at D_1) affected being deposited on a glass substrate at its heating up to the temperature $T=150^0$ C to avoid the influence of volatile constituent phase (task 5).

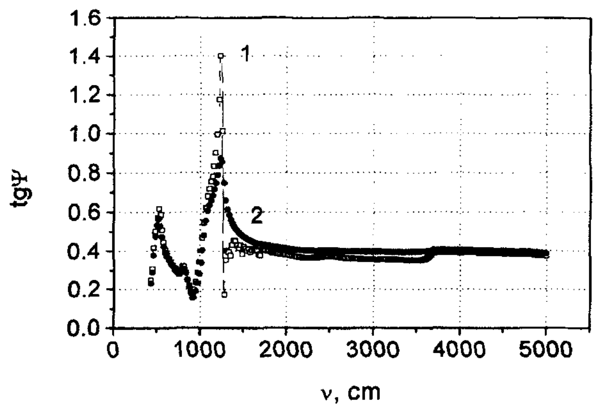
RESULTS AND DISCUSSION

In connection with *task 1* one can make sure that depending on the distance D from a vaporiser to a sample in the spectra tg$\psi(\nu)$ and $\Delta(\nu)$ of BR dye film the absorption band at the wave numbers in the vicinity of 1250 cm^{-1} is occurred in different ways. At $D=D_1=10\text{-}15$ cm such band is sharper (Fig. 1) in comparison with a similar band for WS at $D=D_2=40$ cm. Having compared the corresponding spectra tg$\Psi(\nu)$ at D_1 and D_2 one can also notice that in spectrum tg$\Psi(\nu)$ for WS ($D_2=40$ cm) the maximum is shifted to the short wave range by 10 cm^{-1} at least whereas the distinct minimum disappears at all. It is interesting to note that no any shift is observed for the maximum in $\Delta(\nu)$ spectrum due to changing D. Hence WS might be prepared at smaller distance than that just selected due to diminishing efficiency of a deposition rate for such BR dye.

In the framework of *task 2* it was found that BO dye film at the mentioned values of its thicknesses prepared on silicon substrate occurred less as compared to that deposited on a glass. Thus, the usage of the ellipsometric method in the middle infrared for an estimation of the thicknesses of such kind of films might not be efficient [3].

With respect to *task 3* it is necessary to emphasise the following. Due to spectra tgψ and Δ obtained for the one-layer system (Cr film previously deposited on a glass substrate) the deposited metallic film is proved to be ultra-thin because the differential signals in both spectra in accordance with FS and SF measurements are scarcely noticeable.

That is why spectral dependences for a double layer system containing BO dye are just similar in the details to those measured in the framework of *task 1.* Hence for improvement of the adhesion properties of such recording material owing to acquisition of interstitial Cr film before dye film deposition it is necessary to select the Cr heating temperature above 1000^{0}C.



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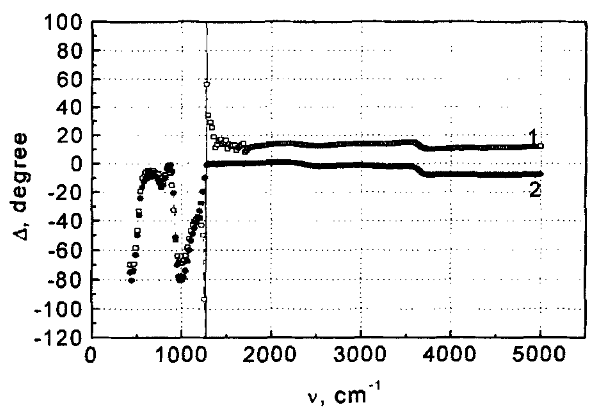
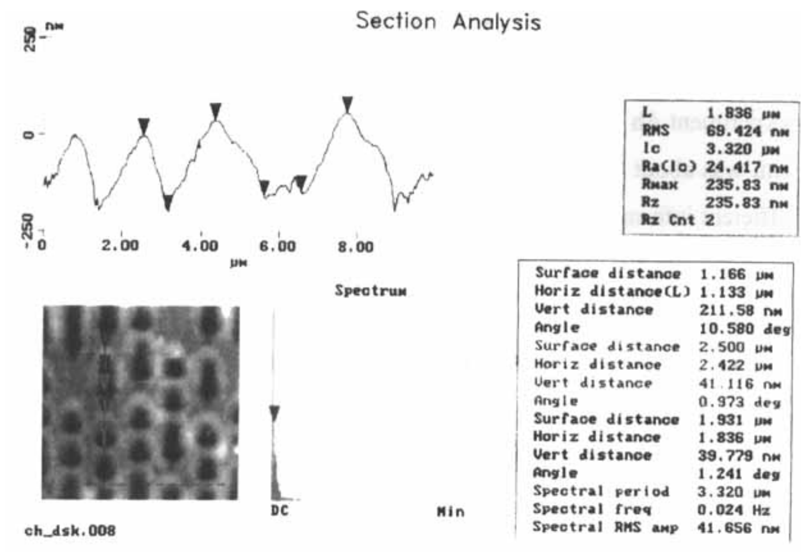


b

FIGURE 1 Spectral dependences of tgΨ(a) and Δ (b) for BR dye film deposited at $D=D_1=10\text{-}15$ cm due to FS(1) and SF (2) system measurements.

In connection with *task 4* the results acquired are also similar to those obtained in *task 2*. The only diversity consists in red-shifting by 5 cm^{-1} for the fundamental absorption band of OR dye in the vicinity of 1250 cm^{-1} range due to $tg\psi(\nu)$ spectrum as compared with such band of BO dye film in the same spectrum. It is necessary to emphasise that in turn the analogous band of BR dye film is also red-shifted by 5 cm^{-1} with respect to the corresponding band of OR dye film. In accordance with *task 5* it is possible to find in $tg\psi(\nu)$ spectrum the displacement of the absorption band of OR dye film into the short wave range nearly by 5 cm^{-1} . This effect is in the manner similar to that obtained in *task 1* for WS. Then the velocity of a deposition for such organic dyes owing to the mentioned substrate heating decreases.

As an example the information in a pit form is recorded on OR dye film by using the second harmonic radiation of Nd-laser and appropriate recording surface structures of this film probed by scanning tunnel microscope after the laser irradiation with the power of 4 mWt and 10 mWt are depicted in Fig. 2, a and Fig. 2, b respectively. The ring-like pits corresponding to 3τ impulse extent of laser irradiation as well as the ellipse-like ones are determined by its 11τ impulse extent at τ=231 ns accepted as a standard for compact disk during information registration. The spatial spectra for appropriate curves of microrelief acquired are also shown in Fig. 2 along with representation in the upper insertions for each curve of such parameters as a distance L between tracks on the disk, the Fuorier coefficients R_Z, R_A as well as other surfaces. The characteristics between neighbouring marker pairs for these curves are presented in the lowest tables near the corresponding curves. The depth is proved to be equal to the thickness of OR dye film and the process of a hole formation is likely to be similar to that described earlier [4].



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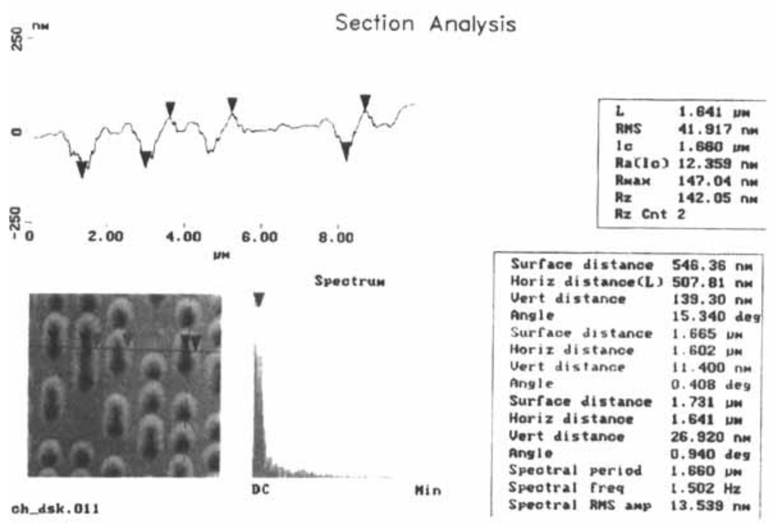

b

FIGURE 2 Pit structure on the OR dye film obtained at laser irradiation powers of 4 mWt (a) and 10 mWt (b).

The height of a rim may be estimated due to relationship [5]: $\Delta h=2(r_0h_0/2\pi)^{1/2}-h_0$, where r_0 is a radius of the focused laser pattern, h_0 is a pit depth and in our experiment Δh is approximately equal to 40-60nm.The calculated height of a rim was about $(1/6)h_0$ and thus its value agreed well with those required for efficient information recording on a base of dye films.

CONCLUSIONS

1. All the dye films are anisotropic because a value of the $tg\Psi$ exceeds 1.
2. The estimation of the thicknesses d of the formed dye films on a glass substrate by solution of inverse ellipsometric task is efficient at d~100nm. The most sensitive ellipsometric parameter to d changing due to decreasing D is the phase shift between p- and s- components of polarisation vector of the reflected light beam.
3. The most efficient optical recording of the information in a pit form on such kind of dye films by using the second harmonic radiation of Nd-laser with its power of the order of 4-10 mW is realised by 3τ impulse extent (τ=231 ns) at the pit depth as great as 40-60 nm.

Acknowledgements

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