Polarization Controlling by Microcomputer

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Abstract

There are obvious advantages of being able to produce and control the state of polarization. The advantages include the continuity of the data measurement and speedy acquisition. In this work, a technique of phase modulation that controlled by microcomputer has been developed. This technique based upon a rotation the quarter wave plate (QWP). It was found that the experimental results are satisfactory and the output characteristics are slightly different from the preliminary theoretical analysis.

Keywords: polarization controlling, microcomputer

1. INTRODUCTION

Polarization modulation techniques allow control of the state of polarization and modulation of the phase difference. [1,2] Polarization compensatory converts an arbitrarily changing state of polarization to a prescribed state, usually a linear polarization in the preferred direction. They are useful in coherent optical system and optical switches, since polarization-dependent optical switches are easier to design than polarization-insensitive ones. Endlessness is an important characteristic in a polarization control system. Rotating half-wave plate and quarter-wave plates are important building blocks for it [3]. Previous studies of rotating wave plates include mechanical rotator [4], $LiNbO_3$ device [5]. They are either bulky, slow, or require high voltage especially $LiNbO_3$ or have problems of insertion loss in case of fiber-optic. The prototype our instrument set can be adapted to polarimeters and ellipsometer [6]. In our work, we control the state of polarization using a rotation quarter wave plate by microcomputer. Precise state and orientation of polarized light at any instant of time are obtainable. The variation angle of quarter wave plate can be employed to generate to control. The output polarized light, rotating plane polarized beam, and orientates at a desired azimuth via the phase modulation. Since the instrument has controlled and measured some important factors by microcomputer, so that the final results can be shown speedily.

2. BACKGROUND

The basic for generating the rotating plane polarized beam based on the principle of two orthogonal (left and right) circular polarized beams recombine to produce a linear state (Figure1), whose azimuth is dependent on the phase difference between the two circular state.

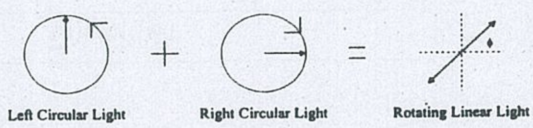

Figure 1 Schematic of combination of two opposite circular polarized beams to form a linear polarized state.

The optical polarization modulator arrangement can be described in terms of the polarized light beam from a He-Ne laser $(\lambda = 632.8\ nm)$, which is given by

$$\bar{E}_{input} = \frac{E_0}{\sqrt{2}}\begin{bmatrix}1\\1\end{bmatrix}e^{i\omega_0 t} \qquad (1)$$

where E_0 is the amplitude of polarized light beam, ω_0 is the angular frequency of QWP and t is time.

The transmitted beam from polarizing beam splitter (PBS) strikes the first quarter wave plate (QWP1) at 45° and through the second quarter wave plate (QWP2) pass to the photodetector. The plane of polarization of the light emerging from the polarizer can be controlled by rotate the QWP2. The output beam is measured as a function of the position of the analyzer at any time. Then following the above details, the output vector can be found to be

$$\bar{E}_{output} = Q_{45^0}(M)(\bar{E}_{input})$$

$$= \begin{bmatrix}1 & i\\ i & 1\end{bmatrix}\begin{bmatrix}e^{i(\phi_f)} & 0\\ 0 & e^{i(\phi_s)}\end{bmatrix}\begin{bmatrix}1\\1\end{bmatrix}\frac{E_0}{2}e^{i\omega_0 t} \qquad (2)$$

where M represents the properties of linear birefringence described in terms of a Jones matrix [1], and ϕ_f and ϕ_s are phase retradances corresponding to the fast and slow eigenmodes respectively.

Equation (2) may be rewritten as,

$$\bar{E}_{output} = \begin{bmatrix}\cos\left\{\frac{1}{2}\left(\phi - \frac{\pi}{2}\right)\right\}\\ -\sin\left\{\frac{1}{2}\left(\phi - \frac{\pi}{2}\right)\right\}\end{bmatrix}E_0 e^{i\left(\omega_0 t + \phi_s + \frac{\pi}{4} + \frac{\phi}{2}\right)} \qquad (3)$$

Where $\phi = \phi_f - \phi_s$, which is again a linear state with the azimuth controlled by ϕ.

The intensity of the output may be given by,

$$I_{output} = (\bar{E}_{output})(\bar{E}_{output})^* = I_0 \qquad (4)$$

where $I_0 = E_0^2$ = a constant., If an analyzer is introduced before the photodetector, the transmitted electric field will becomes

$$\bar{E}_{analyzer} = A_\theta \bar{E}_{output}$$

$$= \begin{bmatrix}\cos^2\theta & \cos\theta\sin\theta\\ \cos\theta\sin\theta & \sin^2\theta\end{bmatrix}\begin{bmatrix}\cos\left\{\frac{1}{2}\left(\phi - \frac{\pi}{2}\right)\right\}\\ -\sin\left\{\frac{1}{2}\left(\phi - \frac{\pi}{2}\right)\right\}\end{bmatrix}E_0 e^{i\varepsilon} \qquad (5)$$

where A_θ represents the Jones matrix for an analyzer an orientation, θ and $\varepsilon = \left(\omega_0 t + \phi_s + \frac{\pi}{4} + \frac{\phi}{2}\right)$.

Consequently, the intensity detected after the analyzer may be given by

$$I_{analyzer} = (\bar{E}_{analyzer})(\bar{E}_{analyzer})^*$$

$$= \frac{I_0}{2}\left(1 + \cos 2\left\{\theta + \left(\phi - \frac{\pi}{2}\right)\right\}\right) \qquad (6)$$

Equation (6) shows that the output signal is a sinusoidal function of the orientation of analyzer, θ and modulation phase, ϕ. This is important in the alignment procedure of the polarization modulation system and its subsequent application.

3. EXPERIMENT AND RESULTS

The experimental set up system is shown in Figure2. In this work, the orthogonal light signals are formed by linearly polarized light from a He-Ne laser ($\lambda = 632.8\ nm$). The angular setting of QWP2 by rotating the QWP2 which controlled by microcomputer. The light from the laser launched into the PBS and passed through a QWP1 with its optical axis at 45°. The QWP1 transforms the outgoing beam into a circularly polarized beam (e.g. right handed). Which is then passed into QWP2 (e.g. left-handed) and produce a second circularly polarized beam. The superposition of two circularly polarized beams (The time varying of phase difference or retardant ϕ between the orthogonal p and s linearization) become the linear polarized beam at any azimuth and depends on the optical axis of both QWPs.

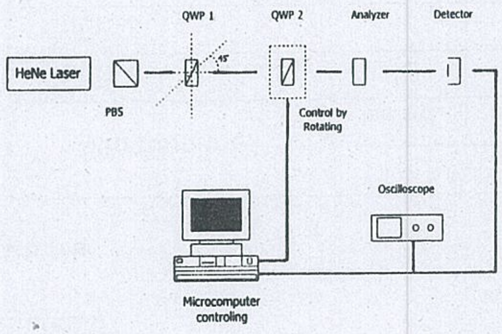

Figure 2: The experimental set up
QWP: Quarter wave plate
PBS: Polarizing beam splitter

The characteristics results as a function of time shown in Figure3. Illustrating the detected output intensities from the arrangement was obtained when an analyzer in the detection to the chosen references direction.

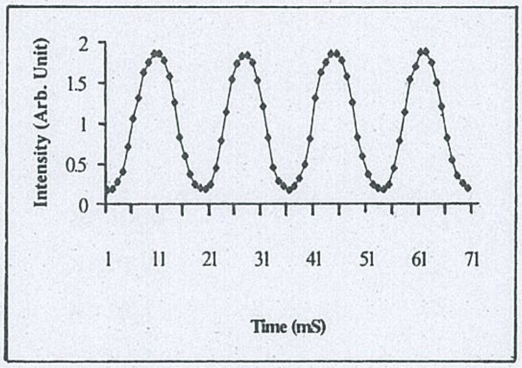

Figure 3: Intensity of output linear polarized beam at any time

The experimental result, as Figure3 is an intensity of linear polarized beam through the analyzer. The optical results include speed of phase change ϕ. And the obtained results are in good agreement with the preliminary analysis from equation (6).

4. CONCLUSION

The preliminary results that obtained from the polarization modulation system were satisfactorily and were slightly different orientation. The experiment analysis obtained of output beam revealed that the optical scheme had better performance and the operating speed and was therefore, most appropriate for polarization sensitive application such as ellipsometry, phase shifter, sensor device and communication.

This present method can be applied to measure the optical properties of some materials by using together with ellipsometry method or polarimeter such as for measure the index of reflection, dielectric constant of liquid crystal and the concentrated of sugar in blood.

5. CKNOWLEDGMENT

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