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B—3—5 A Novel Integrated Optical Bistable Device

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Optical bistable devices (OBDs) are expected as essential elements for optical information processing. Many reports have been published about OBDs. The OBDs are classified into two groups. One is achieved by using a variety of nonlinear optical materials.[1] These materials show the nonlinear dependence of refractive indices on the incident light power. To achieve the bistable condition, however, it requires very high intensity of light. The other is achieved by using a "hybrid" technique.[2] The light which passes through an electro-optic (EO) material is detected by photodetector, and the output voltage is applied to the electrodes on the EO material to modulate the refractive indices. The "hybrid" OBDs reported to the present, however, require an external amplifier to obtain a sufficient drive voltage.

In this paper, we report a novel integrated OBD in which the electrical feedback loop is integrated monolithically. Figure 1 shows a scheme of proposed optical bistable device in which interdigital electrode Bragg deflector and amorphous silicon photovoltaic detector are integrated on Ti-indiffused Y-cut $LiNbO_3$. The principle of operation is as follows. The light Pi incident on the Bragg deflector is divided into transmitted light Pt and reflected light Pr. The transmission efficiency Pt/Pi of the Bragg deflector is given by following equations.[3]

$$Pt/Pi = \beta\cos^2(\pi\Delta nd/\lambda_0\cos\theta)+\alpha, \quad \Delta n = 0.5\gamma_{33}n_e{}^3E$$

Where Δn is an induced refractive index change, d a width of the Bragg deflector, λ_0 a free space wavelength, θ a Bragg angle (a function of grating pitch), γ_{33} an electro-optic coefficient, n_e an extraordinary index, and E an applied electric field. Figure 2 shows an example of calculated results which shows the dependence of Pt/Pi on the output voltage V [A], and the dependence of the V on the Pt with the Pi as a parameter [B]. As the Pi increases, the Pt moves from a to c. As the Pi exceeds 0.028 mW, the Pt jumps from c to d. Figure 3 shows the dependence of the Pt on the Pi with the voltage which gives minimum Pt/Pi as a parameter. It shows the hysterisis characteristics of bistable operation.

In the experiment, the Bragg deflector with 2 μm pitch, corresponding to

Θ=1.04°, was fabricated on the substrate. The detector, 20 amorphous silicon photovoltaic cells connected in tandem (as shown in Figure 1), produced the maximum voltage of more than 12 V. Figure 4 shows the characteristics of Pt as a function of Pi. The differential amplification at Pi=0.065 mW and the bistability with hysterisis between Pi=o.12mW and 0.15 mW correspond to the 1st and 2nd lobes of the Pt/Pi curve which differed from the ideal cos curve [A] shown in Figure 2.

In conclusion, a novel OBD integrating electrical feedback loop has been experimentally shown. Amorphous silicon photodetector is easily deposited on any place of the substrate, and the feasibility of the fabrication of complex OBDs will be expected.

References

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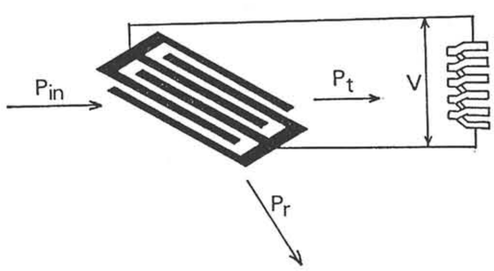

Figure 1. Schematic diagram of Integrated OBD

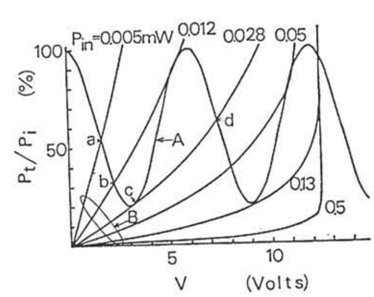

Figure 2. Dependence of Pt/Pi on the output voltage V [A] Dependence of V on Pt with Pi as a parameter.

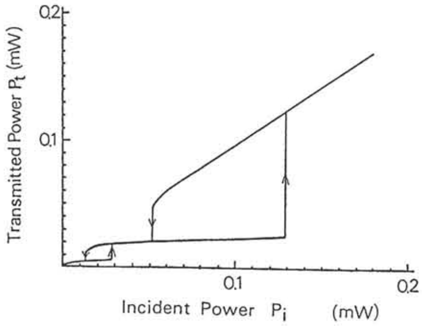

Figure 3. Hysterisis characteristics of OBD.

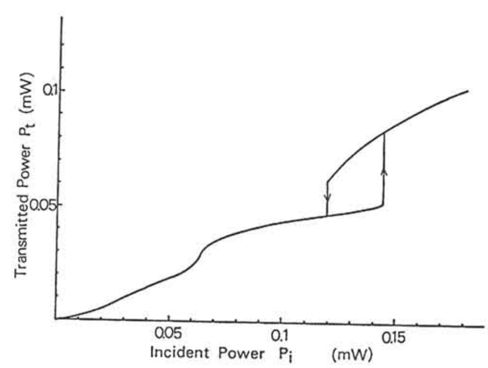

Figure 4. Experimental result.