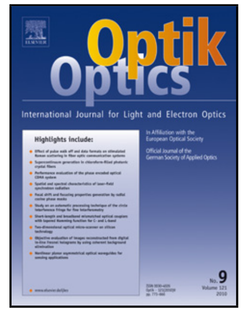

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Optimizing low half-wave voltage electro-optic polymer modulator for optical waveguide sensor

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Abstract: Electro-optic (EO) modulator is used commonly in optical communication systems. Extensive research has being carried out to optimize the device by improving its design and making use of novel waveguide materials. For bio-sensing applications, optimizing the device to be able to operate in low frequency and low input voltage (half-wave voltage) are substantial. This paper discusses the ability of a selection of EO modulator materials and waveguide designs to increase the modulator's sensitivity by enhancing the value of the EO coefficient and reduce the half-wave voltage needed to modulate the input signal. EO phase modulator with a proper polymer material will produce better results compared to $LiNbO_3$ in terms of length extension and low insertion loss. Furthermore, we show the performance study of a EO polymer phase modulator compared with the $LiNbO_3$ waveguide to gain lower length extension as well low insertion loss. Those parameters are essential for bio-sensing applications like as biomedical tools to sense the response of human body. As well as these parameters are important to design an EO phase modulator that is feasible for measuring bio-potential signal of a human body in biomedical applications.

Keywords: Electro-optic modulator; polymer waveguide; Pockel's coefficient; half-wave voltage; optical sensor.

1. Introduction

Recent decades have seen exponential growth of demand on the telecommunication services. This demand has required an exponential growth in bandwidth which has made electro-optic (EO) modulators vital in the efforts to provide external, high-modulation bandwidth while minimizing the effects of optical fiber dispersion [1-3]. The optical properties of a waveguide material with an applied voltage in a controlled way are the essence of the electro-optic modulators.

The changing of propagation wave through the EO modulator opens the opportunity to be utilized as sensing instruments. The EO modulator in sensing technologies has a potential to be viably developed as a practical, distinctive method adopted to detect electric fields [4] and bio-potential signals [5]. Optical sensing solutions in biomedical applications have an innate advantage of immunity to both RF and magnetic field interference. In specific, the optical sensing shows an alternative choice for the sensing of surface bio-potentials, where there is the existence of electromagnetically noisy environments or safety requirements that entail a high level of galvanic isolation in those circumstances. Although, the optical properties, particularly low signal amplitude and high source impedance of typical bio-potentials have provided optical transduction an unfamiliar sensing method [5]. The complexity of directly measuring myocardial signals from the skin surface using the optical technique is compounded because of the amplitude of the bio-potential noted from the cardiac activity is extremely low (being in the 10's of μV range).

The voltage required to make a π-phase shift is called the half-wave voltage (V_π). The Vπ depends on the length of the electrode l, gap between electrodes d, linear electro-optic. This relation can be written as in the Equation (1):

$$V\pi = \frac{\lambda d}{n^3 r_{33} \Gamma L} \qquad (1)$$

where λ is the wavelength, r_{33} is the EO coefficient, Γ is overlap integral factor, *n* is the effective index, where it response to the electric field to change the phase in modulator.

2. Theory

A number of possibilities that can improve the low input voltage requirement of the EO modulator are examined. regarding the relationship of the E-field, The E-field changes the crystal's refractive index,

$$\Delta n = n_0^3 r_{33}\left(\frac{E}{2}\right) \qquad (2)$$

where n_0 is the refractive index. This electro-optic effect enhances the photorefractive effect when the photo effect and