Simulation of a High Speed Interferometer Optical Modulator in Polymer Materials

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ABSTRACT

In this work, the design and simulation of a high speed (300 GHz) electrooptic modulator operating at 1550-nm wavelength is presented. As electrooptic active material, a nonlinear optical polymer with highly nonlinear chromophores dispersed in an amorphous polycarbonate is used. Optimization of modulator geometrical structure and extraction of device performance parameters are obtained by 3D simulations.

INTRODUCTION

The electro-optic (EO) polymer modulators have been investigated for more a decade, because of their low index dispersion at millimetre wave frequencies, low cost, large electro-optical coefficients, and easy integration with electronic circuits. Polymer based technology has allowed to demonstrate ultra-fast EO Mach-Zehnder modulators, having wideband frequency response to over 100 GHz and low driving voltage [1]. Guest-host polymers are used, consisting of highly nonlinear chromophore and amorphous polycarbonate (APC) or polymethylmethacrylate (PMMA) as active EO material. When doped into amorphous polycarbonate host (ACP), phenyltraene-bridged chromophore (CLD-1), gives an EO coefficient r_{33} of 90 pm/V (@1060 nm) and loss of 1.2 dB/cm (@1550 nm) [2].

In the proposed modulator, CLD-1/ACP is assumed for core layer, UV15 (an UV curable epoxy) and UFC17 (a polymer that doesn't contain any solvent) are used for lower and upper cladding, respectively.

MODULATOR DESIGN AND SIMULATION

The interferometer optical modulator (whose geometry is shown in Fig. 1) has been 3-D simulated using BPM [3]. The quasi-TM single-mode behaviour of its rib waveguide has the field profile shown in Fig. 2. To optimize the Y-branch power splitter geometry, composed by a parabolic taper and an arc cosine branch, we have simulated the modulator without any RF signal applied and examined its optical field at the output (Fig. 3).

Polymer modulator bandwidth is limited only by the conductor loss because the microstrip electrodes are engineered to achieve $n_m \approx n_{opt}$ (being n_m and n_{opt} the microwave and optical effective index, respectively). Thus, modulator 3-dB bandwidth is:

$$f_{-3dB} \approx \left(\frac{3.2}{aL}\right)^2 \quad (1)$$

where L is the interaction length between RF and optical signals and a (0.48 dB/cm$\sqrt{\mathrm{GHz}}$ for Au electrodes) is the loss coefficient of transmission lines. To obtain a 300 GHz 3-dB bandwidth, the interaction length (L) has to be 16 mm long (Fig. 4).

Simulating the modulator behaviour when a RF signal is applied to the electrodes, we have determined the half-wave voltage as $V_\pi = 4$ V, and obtained the relative power versus propagation length diagram, as sketched in Fig. 5.

Finally, the DC characteristic of the proposed modulator has been obtained (see Fig. 6) and the extinction ratio calculated as ER = 28 dB.

REFERENCES

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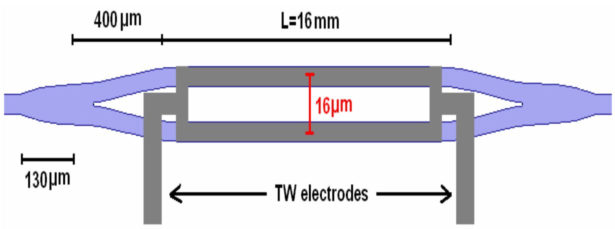

Fig. 1. Proposed EO modulator geometry.

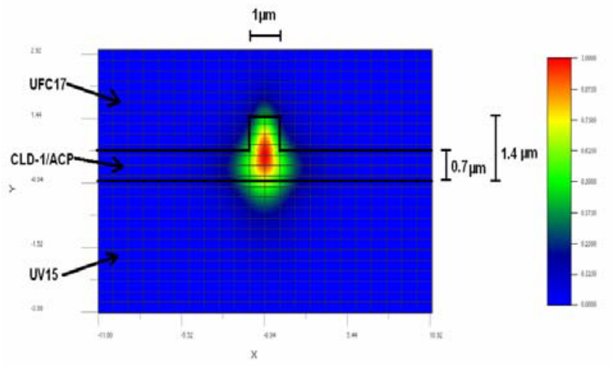

Fig. 2. Quasi-TM mode profile.

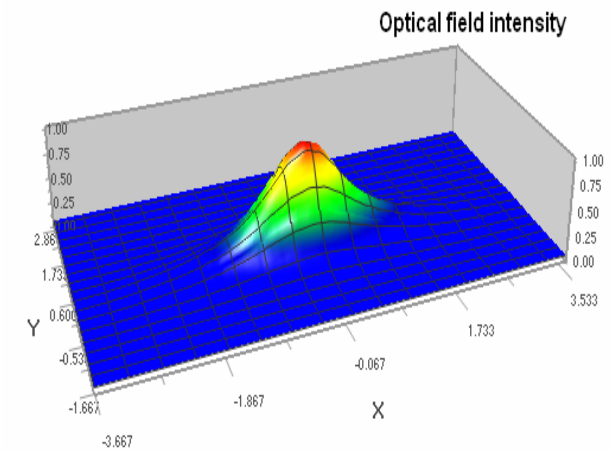

Fig. 3. Optical field intensity at the output cross section.

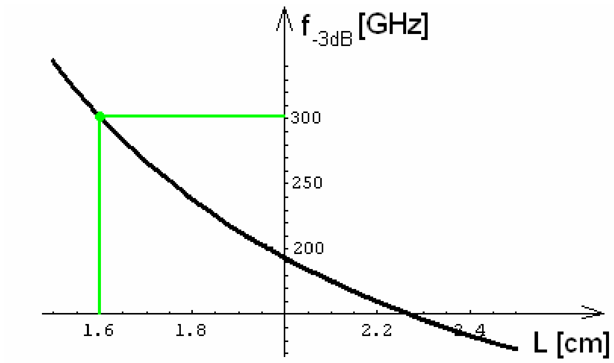

Fig. 4. Modulator 3-dB bandwidth versus interaction length between RF and optical signals (Au electrodes).

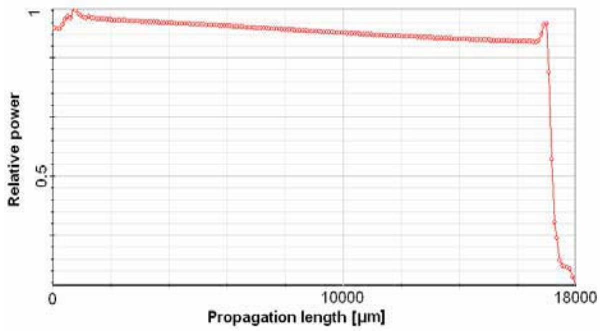

Fig. 5. Relative power versus device length when V_{π}= 4V is applied to the electrodes.

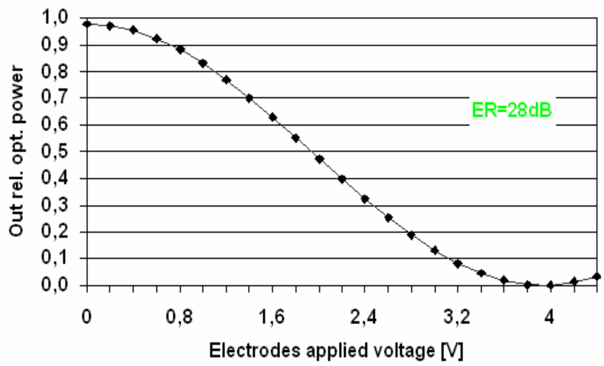

Fig. 6 EO modulator DC characteristic (extinction ratio 28 dB).