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A novel TiO_2/electro-optic polymer waveguide modulator

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In this work, we have fabricated a waveguide using a TiO2 core and an EO polymer cladding. As the high refractive index TiO2 core is thin, a large fraction of the optical TM mode extends into the cladding, which is the rationale for selecting an EO polymer cladding [1]. As a result, our waveguide can be constituted without a transparent cladding, which makes the interelectrode gap smaller than the traditional three-layer waveguides. This TiO2 layer also has the function of improving the poling efficiency of the EO polymer to attain a high r33 level, due to the blocking of excessive charge injection and the reduced the current leakage. Combining all of these merits together, the resulting fabricated waveguide exhibited a VπL figure of merit and propagation loss of 3.3 V·cm and 3.0 dB/cm, respectively.

Figure 1(a) shows the designed cross-sectional structure of the waveguide. The thickness of EO polymer cladding is 2.4 μm [2]. The height and width of the TiO2 ridge is 0.1 μm and 2 μm, respectively. The thickness of the TiO_2 slab section is 0.15μm. Figure 1(b) indicates the simulated TM_0 modal pattern across the waveguide. It can be observed that there is a discontinuous mode at the boundary between the TiO_2 and the EO polymer and that more of the optical mode extends deep into the EO polymer layer. This is caused by the discontinuity of the electric field at high-low refractive contrast interfaces. According to the calculation, the optical loss and overlap factor is 0.7dB/cm and 48%, respectively.

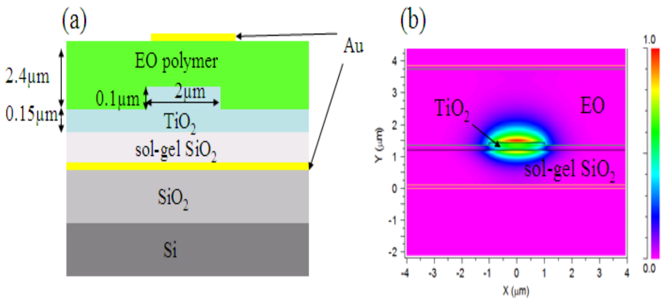

Fig.1 (a) Designed cross-sectional structure of the TiO_2 /EO polymer waveguide, and (b) simulated TM_0 modal pattern

Based on these simulations, a TiO_2 core and EO polymer cladding waveguide was fabricated [3, 4]. To obtain the EO properties, the waveguide was observed as light intensity modulation using a cross-polarization setup. The V_π of the modulator was obtained by measuring the relationship between the applied DC voltage and transmission. Figure 2 exhibits the transmission plotted against the bias voltage. It can be seen that the V_π of the waveguide is ~15 V. Considering the Au electrode length of 2.2 mm, the $V_\pi L$ figure of merit is 3.3V·cm. Since this straight shape waveguide is possible for the application of a push-pull MZI structure, the drive voltage can be further reduced to the half voltage level.

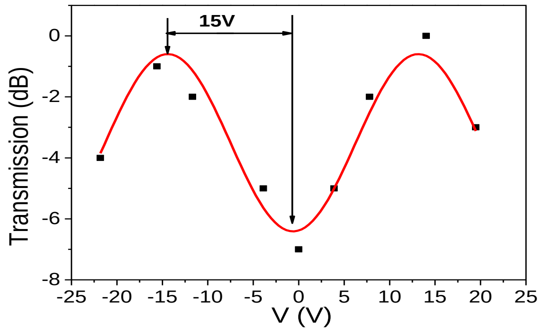

Figure 2 Transmission through the device as a function of bias voltage

By using the measured $V_\pi L$ of 3.3V·cm, an effective in-device r_{33} was estimated to be ~120pm/V. To compare the poling efficiency, we also measured the r_{33} of a thin EO polymer film and a TiO_2/EO polymer double-layer film on ITO glass. The measured r_{33} was 69 pm/V for the thin EO polymer film, while r_{33} was 125 pm/V for the TiO_2/EO polymer double-layer. This ~80% overall improvement in the r_{33} value is attributed to the function of the TiO_2 layer, which has been predicted by the field distribution flattening effect [3].

References

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