

Integrated low drive voltage electro-optic Bragg modulator using a periodically poled lithium niobate

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Periodically poled lithium niobate (PPLN) is currently used for frequency conversions using quasi-phase-matching, thanks to its high nonlinear coefficients and mature poling process. PPLN can also be attractive for electro-optic (EO) applications. Several studies have been conducted on PPLN-based EO deflectors, and recent realizations have lower the required applied voltage under hundred volts [1]. Indeed, for practical EO applications drive voltages as low as 5 V are usually required. For this purpose, we use a recent technique to realize high-quality isolated crystalline film out of LN [2] to implement an EO Bragg deflector with a drive voltage below 10 V. In this work we present an efficient spatial light deflector working for extraordinary or ordinary light polarization using the EO effect in a thinned PPLN planar waveguide confined between two silica layers on a silicon substrate, which allows the deflection of the light under the effect of a low electrical voltage.

To this aim, after the periodic poling of a 500- μm -congruent LN wafer, a thin silica layer is deposited onto one face of the poled wafer, followed by the sputtering of a gold layer. A 500- μm -thick silicon wafer is also coated with a gold layer. The metalized faces of both the PPLN and silicon wafers are then placed into contact and pressed in a wafer-bonding machine. The LN layer is then mechanically ground and polished to get a LN film with a thickness of 5 μm . A second silica layer is deposited on the top surface of the PPLN. Finally, two gold electrodes are deposited to allows the application of a uniform electric field to activate the EO effect.

As schematically shown in Fig. 1. (a), the PPLN waveguide structure works as a spatial light deflector with two output ports driven by the EO effect. Fig. 1. (b) displays the obtained results. The experimental η_{exp} and theoretical η_{th} diffraction efficiency versus the applied voltage U are represented. More than 97% of diffraction efficiency is obtained with an operating wavelength of 633 nm for the two orthogonal light polarizations with a drive voltage of about 5 V [3]. We also design an EO Bragg filter using a PPLN ridge waveguide. The structure aimed at filtering a wavelength from a broadband spectrum between 1500 nm and 1600 nm delivered by a broadband source for telecommunication applications.

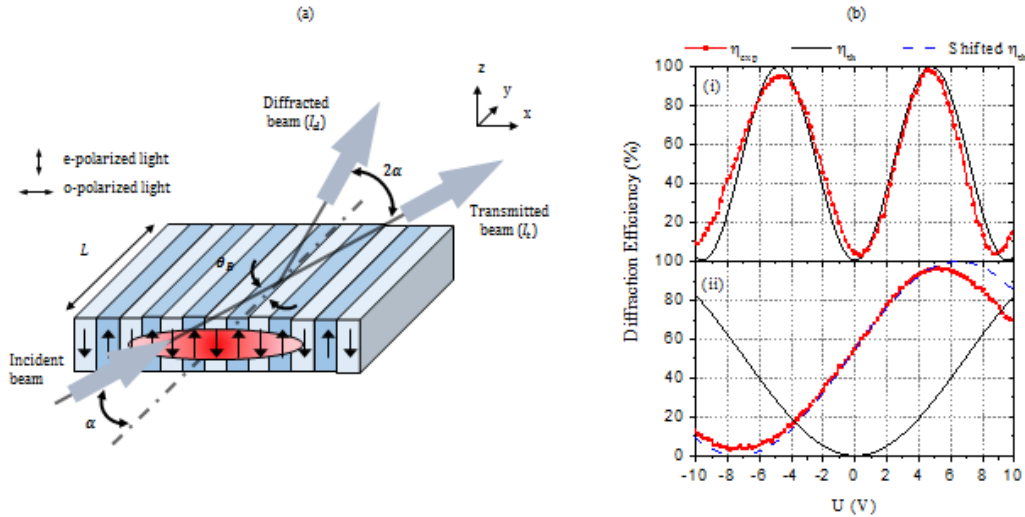


Fig. 1 (a) Configuration of the waveguide electro-optic Bragg deflector tested both with ordinary (o) and extraordinary (e) light polarizations. (b) Diffraction efficiency versus applied voltage U for (i) e-polarized light and (ii) o-polarized light. Red points are experimental data. Black solid lines are theoretical curves. The blue dash line in (i) is shifted from the latter by an offset $\Delta U_0 = -7.5$ V due to the presence of a permanent internal electric field and to a surface grating resulting from the thinning process.

References

- [1] M. Okazaki and T. Suhara, "High-performance 1024-pixel EO spatial light modulator using cascaded periodically-poled Raman-Nath gratings", *J. Lightwave Technol.* **33**, 5195 (2015)
- [2] M. Chauvet, F. Bassignot, F. Henrot, F. Devaux, L. Gauthier-Manuel, H. Maillotte, G. Ulliac, and B. Sylvain, "Fast-beam self-trapping in LiNbO₃ films by pyroelectric effect", *Opt. Lett.* **40**, 1258 (2015).
- [3] I. Mhaouech, V. Coda, G. Montemezzani, M. Chauvet, L. Guilbert, "Low drive voltage electro-optic Bragg deflector using a periodically poled lithium niobate planar waveguide", *Opt. Lett.* **41**, 4174 (2016).