

All-optical electric field sensor in domain inverted LiNbO₃ for harsh environment

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Optical high-voltage sensors have outstanding advantages in terms of isolation and immunity to electromagnetic interference. So far, several configurations have been proposed, mostly based on integrated Mach-Zehnder interferometers [1] or polarization/phase rotation in piezo-electric crystal [2]. While the first scheme requires initial electrical bias to compensate for the phase mismatch between the two arms, the second one requires interrogation or phase noise reduction systems that are expensive to implement. Near cut-off optical waveguide devices have been already reported in LiNbO₃. In particular, the use of waveguides at cut-off was proposed for modulation in the field of optical communications [3,4] and sensing [5]. We present a novel integrated optical high voltage sensor based on a Z-cut LiNbO₃ which operates without any metallic parts. The proposed device is sketched in Fig. 1 (left). An annealed proton exchange (APE) waveguide near cut-off is fabricated in Z-cut LiNbO₃ and centered in a domain inverted region. The application of an external electric field parallel to the z axis of the device produces a refractive index change Δn_{\pm} between positive and negative domains given by $n_e^3 \cdot r_{33} \cdot E$, where E is the intensity of the external electric field along the z-axis, $n_e=2.14$ and $r_{33}=30.8$ pm/V are the refractive index and the electro-optic coefficient along the z-axis, respectively. As a consequence the optical mode will broaden so that, after a sufficient propagation length, a loss is produced due to a mode-profile mismatch of the guided modes between active and passive regions.

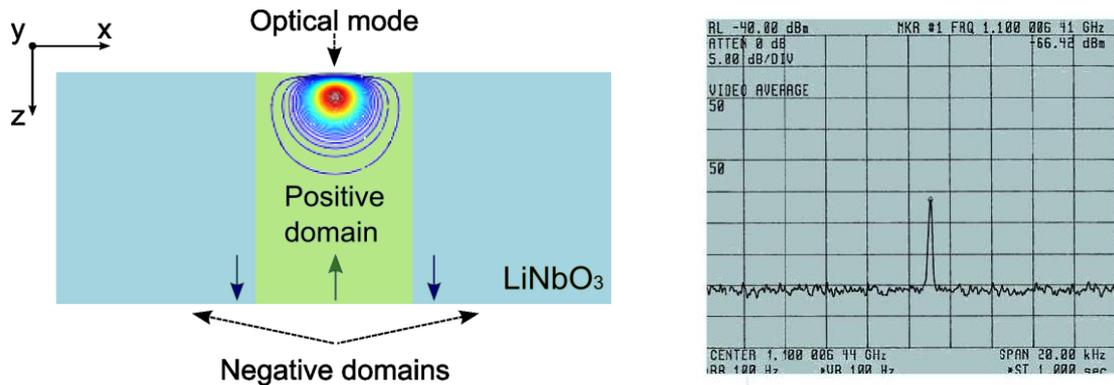


Fig. 1 (left) Cross-section schematic of the electrode free sensor and, (right) A typical RF signal detected by the sensor at 1.1 GHz

We demonstrate the sensor principle by detecting DC field up to 2.6MV/m. Moreover, we tested the device at 1.1 GHz. The RF signal was supplied by an HP8642 signal generator and radiated by a microstrip patch antenna and a typical spectrum of detected RF at 1.1GHz is shown in fig.1 (right). In our experiments, we were able to detect RF field intensities ranging from 19V/m to 23KV/m.

More details about the characterization of the device and alternative geometries will be presented at the Conference.

References

- [1] T.H. Lee, et al., "Electromagnetic field sensor using Mach-Zehnder waveguide modulator," *Microwave and optical technology letters*, **48**, 9 (2006)
- [2] G. Gaborit, L. Duvalaret, "Electro-optic sensor: towards vectorial electric field characterization," ECIO '05, Grenoble, 2005
- [3] A. Neyer and W.Sohler, "High-speed cutoff modulator using Ti-diffused LiNbO₃ channel waveguide," *Appl.Phys.Lett* **35**, 256-258 (1979)
- [4] N.H.Zhu, et al, "Proposal for high extinction ratio LiNbO₃ optical waveguide cutoff modulator" *IEEE Proc-Optoelectron* **142**, 248-250 (1995)
- [5] S.S. Lee et al., "Integrated optical high voltage sensor using a z-cut LiNbO₃ modulator" *Phot. Tech. Lett.*, **5**, 9 (1993)