Demonstration of Bloch Surface Waves in crystals with $LiNbO_3$ thin films

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Summary

A novel one dimensional photonic crystal (1DPHC) sustaining Bloch surface waves (BSWs) with a single crystal thin film lithium niobate (TFLN) as a part of a multilayer is theoretically and experimentally investigated. Properties of the dielectric multilayer platform with optical anisotropy introduced by X-cut TFLN are studied.

Concept

Periodic dielectric structures are able to sustain surface electromagnetic modes - called Bloch surface waves (BSWs) - within their photonic bandgaps. These surface states are bound to the interfaces and may show significant field confinement and the potential of higher propagation length due to low loss characteristics of dielectric materials. Due to high quality factor of the BSWs they can be used for sensing [1], [2] and in integrated optics applications [3]. In recent studies amorphous isotropic materials were used for the multilayers and passive BSW based devices were investigated. In order to move towards anisotropic and active tunable devices it will be needed to consider new materials for the multilayer structure. Lithium niobate is a well-known high refractive index birefringent material with tunable optical properties which can be modified by an external physical signal such as electric or magnetic field application. This material is widely used in the field of integrated optics and, used on top of a multilayer it offers the possibility of tunable BSW – loaded functionalities. BSW sustaining system with fixed thicknesses of multilayers, which is working at one chosen wavelength is very sensitive to the refractive index change. By tuning the refractive index of the layers the one can change the parameters of BSW excitation. In the case of X-cut $LiNbO_3$ the change of refractive index also may be achieved by rotating the crystal in such a way that the light propagates along

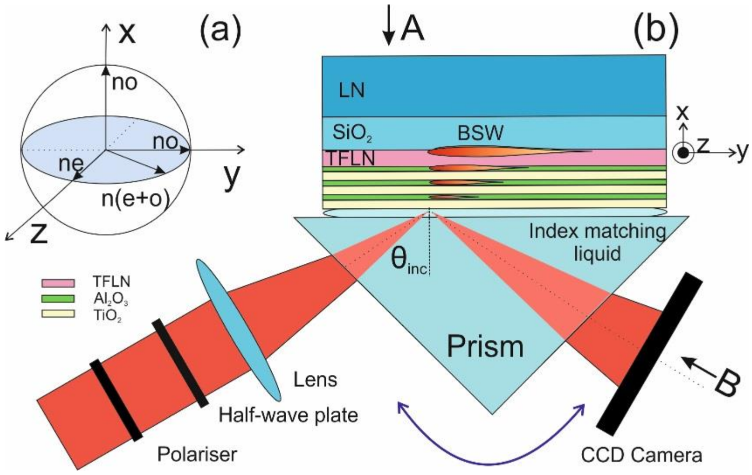

Fig.1.(a). Sketch of index ellipsoid of $LiNbO_3$. (b).Experimental setup.

ordinary or extraordinary axis. Thus the refractive index value will vary from n_o to n_e, where n_o is ordinary refractive index and n_e is extraordinary refractive index. Figure 1.(a) shows the sketch of the index ellipsoid of X-cut $LiNbO_3$. The use of this material as an active layer of the BSW platform brings anisotropic properties to the whole 1DPHC in ZOY plane (see Fig.1).

Experiment

In this work a platform consisting of X-cut $LiNbO_3$ thin film and periodic stacks of alternately deposited Al_2O_3 and TiO_2 layers is designed and fabricated to sustain a BSW at the wavelength of 632.8 nm. A 700 nm thick single-crystal TFLN was prepared by ion implantation and direct wafer bonding to SiO_2 layer deposited on LN substrate [4]. The multilayer stack was grown on TFLN surface by means of atomic layer deposition. In order to excite the BSW, the standard Kretschmann configuration was used. The schematic of the configuration and the 1DPHC is presented in Fig.1.(b). The 1DPHC is designed in such a way that the BSW propagates along the TFLN/SiO_2 interface. Experimental evidence of BSW and tunability as a function of excitation angle are observed.

Conclusions

In this work the conception and design for anisotropic 1DPHC with a layer of X-cut single crystal TFLN was presented. We obtained the BSW on the TFLN/SiO2 interface for TE polarized light and experimentally observed the shift of the reflection dip depending on the 1DPHC orientation in ZOY plane.

References

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