2D Optics on Bloch Surface Waves (BSWs) Based Platform: Polymer Lens and Prism

L. Yu, V. Paeder, T. Sfez, E. Logean and H. P. Herzig

Optics &Photonics Technology Laboratory (OPT), École Polytechnique Fédérale de Lausanne (EPFL), Rue A. –L. Breguet 2, Neuchâtel, Switzerland
email: Libo.yu@epfl.ch

Summary

In this work, we use a novel platform concept based on Bloch Surface Waves (BSWs) and manipulate the BSWs propagation with two-dimensional (2D) dielectric patterns deposited on it. The concept opens a way to realize 2D integrated all-optics systems including sensing functionalities.

Introduction

In recent years, we have demonstrated that a ridge of nanometric thickness on a multilayer acts as an efficient waveguide for BSWs [1]. It opened the possibility to manipulate BSWs with ultra thin polymeric structures and to realize 2D optical components.

The dielectric multilayer is specially tailored to support BSWs with properties unattainable using conventional materials. In particular, the low-loss characteristic of dielectric material enables the propagation of BSWs over large distances and enables large resonance strengths. These properties are highly desirable for a 2D optics platform. Elements such as lenses, prisms, waveguides, resonators or interferometers are easily manufactured, thanks to the surface nature of BSWs.

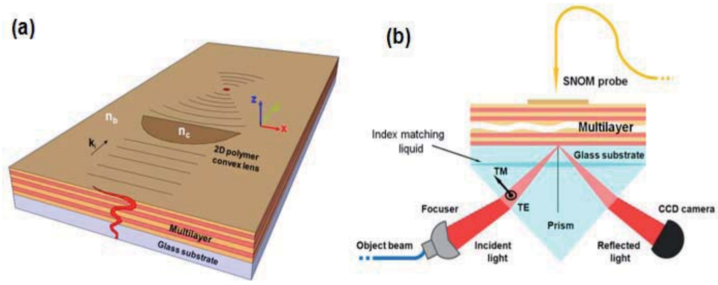

Fig 1. (a) Concept of the 2D plano-convex lens. The field is confined at the surface of the multilayer. An ultra thin convex lens made of AZ1518 is coated on top of the platform; (b) BSWs excitation is performed in the Kretschmann configuration using a BK7-glass prism.

As an example, a schematic of a 2D polymer plano-convex lens is presented in Fig. 1(a). The strong confinement of light in a plane near the surface presents important advantages in very different domains, such as sensing, integrated optics or the study of fundamental optical phenomena. In our studies, BSWs are excited in the Kretschmann configuration [Fig. 1(b)] using a BK7 glass prism. Since all these optical structures imply bounded surface modes, it is crucial to have access to their evanescent tail, if one wants to observe their propagation. The structures will therefore be deeply investigated with the MH-SNOM available in the OPT laboratory [2].

Discussion

First, the propagation constant of BSWs is assessed – in the near field – through an FFT analysis of the measured phase. The effective indices of the BSWs are derived from the obtained propagation constant. The effective indices of the coated structures (lens, prism and waveguide) is n_c = 1.2122 and the index of the bare multilayer is n_b = 1.1465.

The first fundamental investigation of light propagation through 2D optical elements is performed in the near-field on a 2D plano-convex lens appended to a waveguide illuminated with a Gaussian beam. The lens radius of curvature is R = 8.5 µm. The width of the waveguide is 2R and the length L = 50 µm. The lens is positioned approximately at the center of the beam. The measured electric field in the vicinity of the lens is shown in Fig. 2(a). The lens topography is shown in Fig. 2(b). And a finite difference time-domain (FDTD) simulation of the electrical field is shown in Fig. 2(c). The behavior of the light is dominated by diffraction as expected for this small lens (small Fresnel number).

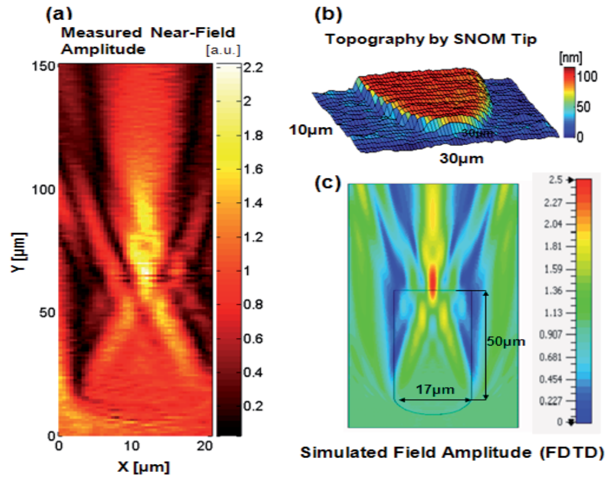

Fig 2.(a) Measured near-field amplitude; (b) topography of the 100nm thin plano-convex lens; (c) corresponding FDTD simulation. The position of the 2D plano-convex lens and the attached waveguide is marked by the closed solid lines. The lens radius is R = 8.5 µm. The waveguide is of width 2R = 17 µm and length L = 50 µm.

The same incident beam is directed at a 2D right-angle polymer prism on the same substrate. The prism topography is shown in Fig. 3(c). The prism is positioned under a condition of total internal reflection (TIR) according to the effective index difference measured above (θ_{TIR}=71.05°). Its schematic is illustrated in Fig. 3(a). The near-field intensity distribution is in Fig. 3(b). It illustrates the path of the reflected and transmitted beams. The intensity-phase map [Fig. 3(d), 3(e)] of the insert area shows the reflection angle by the orientation of the interference pattern which is parallel to the working interface of the 2D prism. The interference is obtained with the first transmitted beam T1 and the total internal reflected beam R1 in Fig. 3(a).

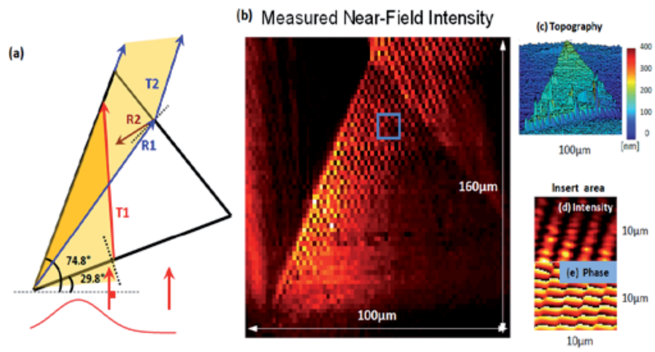

Fig 3. (a) Schematic of the TIR with a 2D right angle prism; (b) measured near-field intensity;(c) Topography of the 100nm thin prism; measured near-field intensity (d) and phase (e) of the insert area marked by a solid square in (b).

Conclusions

In this work, we demonstrate the manipulation of the BSWs propagation through a 2D plano-convex lens and a 2D prism on a dielectric multilayer. Fundamental properties are discussed. The differences between a 2D and a 3D lens are highlighted. This study provides a first step towards the investigation of 2D all-optics systems on BSWs platform.

ISBN 978-3-9815022-4-4

Reference
[1] T. Sfez*, et al.*, *Appl. Phys. Lett.,* vol. **96**, pp. 151101-3, April 2010.
[2] T. Sfez*, et al.*, *Journal Of The Optical Society Of America B-Optical Physics,* vol. **27**, pp. 1617-1625, August 2010.