

Surface modes in one-dimensional Silicon-based photonic crystals

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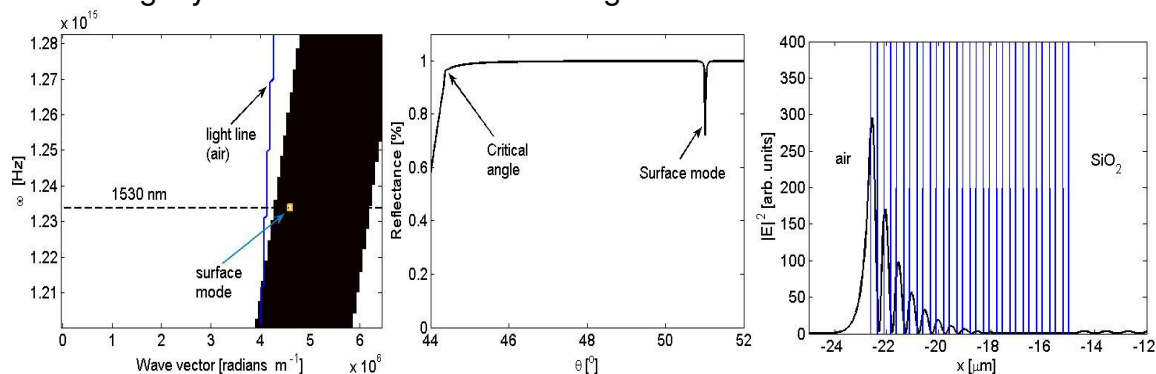
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One-dimensional Photonic Crystals (PC) can behave like standard step-index waveguides. While guided modes in PC are characterized by propagation constants lying in the allowed bands, there exist surface modes located at band edges or perhaps in prohibited bands. Due to their non-radiative nature, surface modes must be excited via evanescent coupling or high-index prism (e.g. using the Kretschmann configuration) [1]. The strong confinement associated to surface modes is connected to an enhancement of the field amplitude close to the air/dielectric interface of the multilayered structure.

We focus on PC based on porous Silicon (p-Si) electrochemically etched in bulk crystalline Silicon and amorphous Silicon Nitride ($a\text{-Si}_{1-x}\text{N}_x\text{:H}$) grown via PECVD on a glass substrate. Thanks to the high accuracy in the control of refraction indexes and layer thicknesses allowed by these two techniques, the optical response of one-dimensional PC can be very finely tuned. Indeed, p-Si and $a\text{-Si}_{1-x}\text{N}_x\text{:H}$ structures showing intriguing luminescence and nonlinear optical effects have been obtained [3, 4]. In the present work we experimentally demonstrate that surface modes can be coupled in the above mentioned stratified structures. Moreover we propose possible surface structuring layouts aimed to a subwavelength transverse confinement of surface waves.



(a) Band structure of an $a\text{-Si}_{1-x}\text{N}_x\text{:H}$ 1D PC in the wavelength range of 1470 nm – 1570 nm. The bright point in the dark region indicates the surface mode. (b) Angle-dependent reflectance spectrum of PC showing enhanced absorption where surface mode is coupled. (c) Spatial distribution of the electric field associated to a coupled surface mode inside the PC.

[1] W. M. Robertson and M. S. May, *Appl. Phys. Lett.* **13**, 1800 (1999).

[2] A. Venturello et al., *J. Non-Cryst. Solids* **352**, 1230 (2006)

[3] S. Lettieri et al., *Appl. Phys. Lett.* **87**, 191110 (2005)