DIFFRACTION-COMPENSATING METAMATERIAL SLAB WAVEGUIDES

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Conventional photonic circuits are based on optical channel waveguides that are typically created on the surface of a planar substrate by etching. In order to be able to transfer optical signals in such waveguides with low loss and without cross talk, their transverse size and separation distance must be on the order of the wavelength, which makes the allowed density of independent optical information channels on the chip low. In this work, we apply the concept of optical metamaterials to the field of integrated nanophotonics with the aim to increase the information transfer capacity in on-chip optical waveguides. The metamaterials we deal with are nanostructured media designed to compensate for optical diffraction.

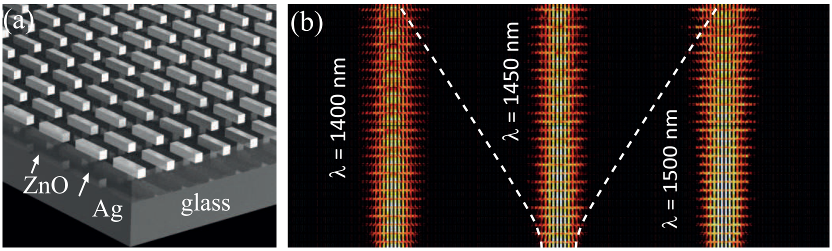

Figure 1: A metamaterial film waveguide. The geometry of the waveguide is shown in (a) and divergence-free propagation of three optical beams in the waveguide is shown in (b).

Previously we have demonstrated a metamaterial design that compensates for optical diffraction in all three dimensions. The material was composed of silver nanorods embedded in glass. In this work, we change the design to a thin film waveguide, in which light is confined in the vertical direction by total internal reflection and in the horizontal direction by the diffraction compensation effect of the metamaterial. The film is made of ZnO with a single layer of silver nanorods embedded in the middle of the film (see Fig. 1a). The waveguide provides divergence-free guidance of tightly focused optical beams in a wide spectral range (see Fig. 1b), which makes it possible to transfer optical signals at THz frequencies. The resulting optical channels can have subdiffraction-limited transverse size. Our recently-developed numerical calculation techniques [1, 2] enable one to design such structures.

[1] V. Kivijarvi, M. Nyman, A. Shevchenko and M. Kaivola, J. Opt. 18 (2016) 035103.
[2] V. Kivijarvi, M. Nyman, A. Shevchenko and M. Kaivola, Opt. Express 24 (2016) 9806–9815.