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# Integrated electro-optical and all-optical waveguide devices with nematic liquid crystals

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The huge availability of liquid crystals (LCs) mixtures with a variety of parameters (including optical birefringence, sign of electrical and optical anisotropy, thermal stability, etc.) allows easy customization of the designed device for specific conditions and allows for an operation in a variable range. There are many non-display applications of LCs in modern photonic systems, which are among others: sensors, diffractive and reflective elements, integrated optical waveguide devices, switchers and routers. A specially design liquid crystal cell with a properly chosen quality of the alignment layer provides switching and routing of optical signal without the need its conversion into electrical signal, possibly the simplest in operation, running stably and allowing for easy implementation in existing fiber optic networks. In this work, we present a specially design and performed liquid crystal cell providing optical signal guiding and routing without the need its conversion into electrical signal, running stably and allowing for easy implementation in existing fiber optic networks. Firstly, we propose an electro-optical induced waveguide that is induced in a NLC layer by applying an electrical field across it, within regions delimited by stripe-shaped or arches-shaped electrodes (fig. 1a). Hence, a refractive index change is produced in this region, which acts as a waveguide core. Light coupled in this region is guided and can be collected at the waveguide output (fig. 1b). It is particularly important in the systems where spatial domains with different refractive indices (in forms of walls and channels) have to be defined (e.g. in practical realization of couplers and switchers).

This approach is pure electro-optic and the switching effect is related only with the applied external voltage. However, it has to be underlined that liquid crystals offer also possibility to guide, switch and route signals thanks to the interplay between light and molecules. In this sense, the use of non-linear beam propagation of the light (in the sense of spatial optical solitons) allows for the construction of an all-optical waveguide switch.

In this approach a well aligned initial state, i.e. specific molecular orientation is desirable. Thus, we will present also the fully-defined and controllable molecular orientation of NLC within waveguiding structures in order to define refractive index distribution within, as well as to obtain efficient and predictable optical effects in proposed devices. By specially design variable initial orientation of NLC molecules we transform our circuits to be independent from the electrical bias (used optionally here only for additional system reconfigurations if required) with the ability to control optical signal direction of propagation and switch between many input and output channels (fig. 1c,d). The light induced waveguide is able to guide second, low power beam which follows exactly the direction of the signal. This "thresholdless" configuration provides low power needed for reorientation effects and is impossible to be achieved with other external factors. There are a vast variety of applications where the properties exhibited by the interaction of light with the optical anisotropy of the LC in a controlled way (when limiting or avoiding external bias) offer enormous design capabilities.

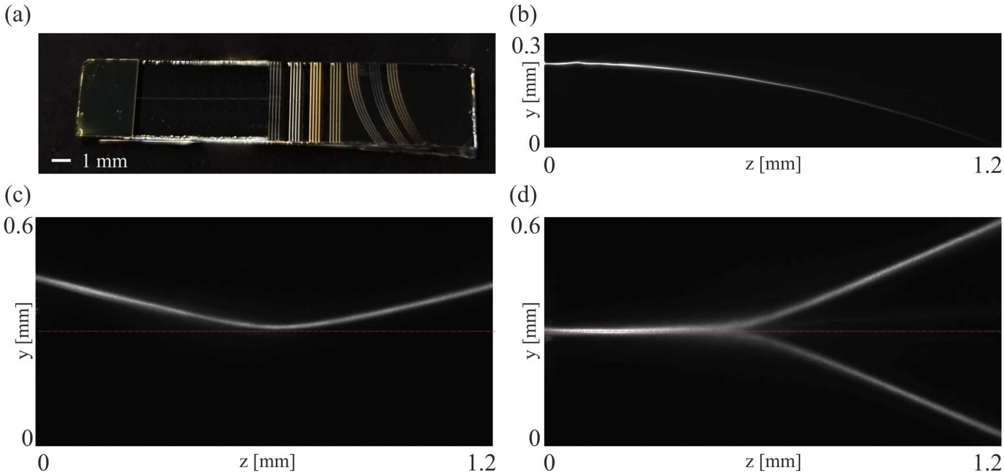


**Fig. 57. a) LC cell with a pattern of stripe-shaped and arches-shaped electrodes for electro-optical induced waveguides; b) beam guiding along arch-shaped and a width of 5 microns electrode; c) reflection of nematicon of the boundary between the two areas with the opposite orientation of the molecules; d) beam splitting due to walk-off effect in adjacent areas of LC cell.**

Our proposed devices concept can be tailored to execute various functions, e.g. interconnections, switching and routing for the specific needs of optical networks.

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