Modifying light propagation in planar waveguides with cladding liquid crystals

Manuel Gil-Valverde, Manuel Caño-García, Eva Otón, Morten A. Geday, Xabier Quintana, José M. Otón

CEMDATIC, Universidad Politécnica de Madrid, Av. Complutense, 30, 28040 Madrid, Spain
e-mail: m.gilvalverde@upm.es

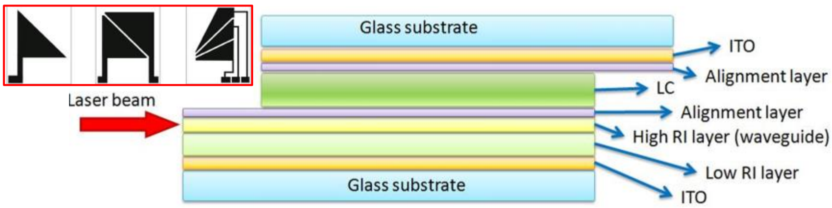

Fig. 1.- Planar beam steering cell. Inset, electrode design

Liquid crystal devices are increasingly being used in non-display applications to manufacture small devices that can be driven by low voltage electronics. LCs are low cost, light weight and avoid using mechanical components. A wide number of interesting applications involve the use of LCs for phase modulation of light. This can be done with light propagating through the LC itself or rather with light propagating in a waveguide (WG) where sections of its cladding are filled with LC that interacts with the light's evanescent field.

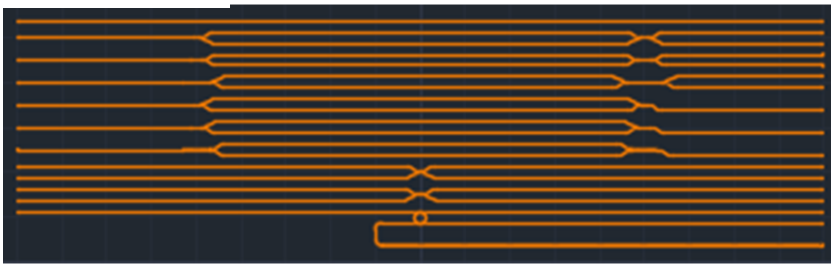

Fig. 2.- Several 1.5×0.5μm waveguide structures for PICs.

Several device families based on this general outline are being tested in our group. The devices can be roughly classified into two categories. The first group consists of WGs having a width much larger than the light wavelength (Fig. 1), therefore behaving as 1D waveguides. In these structures, effective beam steering can be achieved using pixelated electrodes having specific shapes. Beam steering has been demonstrated in IR beams [1] using silicon substrates. In our laboratory, steering of visible light is tested employing, besides silicon substrates, ITO-coated glass substrates with a high-index guiding layer of SU-8.

The second group (Fig. 2) gathers structures –multimodal interference devices (MMI), Mach Zehnder interferometers, ring resonators– that can be inserted into photonic integrated circuits (PIC). LCs deposited onto these structures modify the power of the transmitted light, its wavelength or the ratio between different outputs. Consequently, passive waveguides become active inside the PIC, thus increasing the device performance with a relatively low increase of design complexity [2].

At present we employ silicon wafers for preparing PICs, for the Si conductivity simplifies the connection of the back electrode. Otherwise an ITO-coated glass substrate with a lip for connections is needed. The silicon substrate is coated with a 3 μm SiO_2 layer by sputtering and then SU-8 is deposited by spin-coating and photolithographed using the appropriate mask. A new SiO_2 (1.5 μm) is sputtered on top of the SU-8 waveguides so that symmetric guides are obtained and the surface is flattened. Then a liquid crystal layer is deposited between alignment layers deposited onto the SiO_2 and a top glass-coated ITO layer that completes the structure.

In the near future we intend to associate both kinds of structures for light coupling to different WGs from a single beam steerer.

References

[1] Scott Davis, Scott Rommel, Seth Johnson, George Farca, Neil Rebolledo, Stephanie Selwyn, Michael Anderson, *"Electro-optic steering of a laser beam"* SPIE Newsroom, 10.1117/2 (2011).

[2] M. Caño-García, F. Ye, F. Gordo, M.A. Geday, J.M. Otón, X. Quintana *"Active photonic integrated circuits modulated by LCs"* Conference CLC'16 Krynica-Zdrój, Poland (2016).