Liquid Crystals on Ferroelectric Thin Films

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Barium titanate (BTO) and lead zirconate titanate (PZT) are two of the most common ferroelectric materials used in applications. These two materials offer excellent dielectric, piezo-electric, electro-optic and pyro-electric properties. The excellent electro-optic properties of our PZT and BTO deposited thin films may lead to cheap and versatile ultra-fast electro-optic modulators on existing photonic platforms [1], such as the Si or the SiN nanophotonic platform. In this work however, we exploit the extremely high dielectric permittivity of PZT (in the order of 500 to 1000). The permittivity is quasi independent of the underlying substrate material (glass, glass + ITO, glass + Pt, Si, etc.).

Liquid crystals exhibit electro-optic effects that are an order of magnitude larger compared to PZT, which makes them ideal materials for use in beam steering applications of focus tunable lenses. In these applications the liquid crystal imposes a spatially varying optical path length to light passing through the liquid crystal layer. By working with a number of separately addressable electrodes the optical path length variation can be accurately controlled. Using multi-electrode designs for example, tunable lenses with high optical quality have been demonstrated. One major problem of multi-electrode designs is the appearance of fringe fields which leads to unwanted behavior of the liquid crystal and may eventually lead to the formation of disclination lines which reduces the optical performance drastically. Using a PZT thin film, we demonstrate that the fringe fields are eliminated and that designs with fewer separately addressable electrodes are necessary. Tunable lenses with a liquid crystal layer integrated on top of a PZT layer are demonstrated [2].

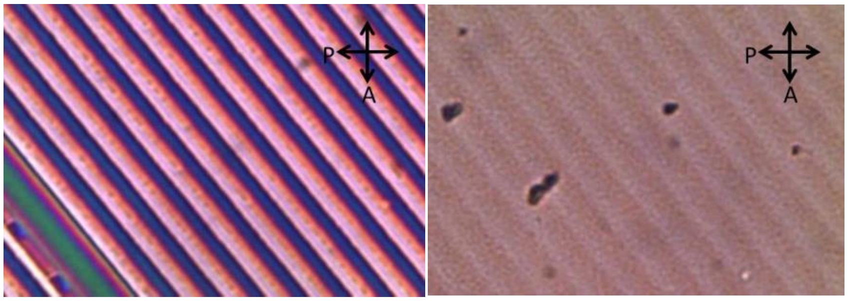

Figure 1. Liquid crystal observed under polarization microscope without PZT layer (left) and with PZT layer (right).

Next to the experimental demonstration we provide numerical simulations of the effect of the high permittivity layer on the liquid crystal.

[1] J.P. George, *et al.* Lanthanide-Assisted Deposition of Strongly Electro-optic PZT Thin Films on Silicon: Toward Integrated Active Nanophotonic Devices. *ACS Appl. Mater. Inter*. 7 13350-9 (2015)
[2] O. Willekens, *et al.*, Ferroelectric thin films with liquid crystal for gradient index applications, *Optics Express* (submitted)