

Bridging the electrode gap with ferroelectric thin films

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Close to the edges of electrodes, strong electric fields are present which often give rise to unwanted effects in liquid crystal behavior. In liquid crystal microdisplays for projector applications, the gap between electrodes should be as small as possible and the liquid crystal orientation should vary sharply from one pixel to the other in order to achieve the highest possible resolution. In other applications however, a smooth variation in the liquid crystal orientation is desirable and fringe field effects are highly unwanted. Electrode based tunable lenses or beam steering devices are examples in which fringe fields should be suppressed as much as possible.

A common way to alleviate the fringe field problem and to smoothen out the spatial variation of liquid crystal orientation is to deposit weakly conductive layers on top of the highly conductive electrodes. In such devices there is a trade-off between high electrical power consumption (high conductivity) and reduced smoothing effect (low conductivity). Also, it is technologically not always straightforward to obtain layers with the desired sheet conductivity. In this work, we demonstrate a new technique exploiting the extremely high dielectric permittivity of ferroelectric thin films based on lead zirconate titanate ($\text{PbZr}_x\text{Ti}_{1-x}\text{O}_3$, PZT). The high dielectric permittivity of the layer leads to similar effects as the conductivity of a weak conductor. The smoothening and spreading of the electrical field lines between two electrodes is clearly demonstrated in figure 1. At the same time we also prove the excellent reduction of fringe fields near electrode edges. Using multi-electrode designs with a PZT top layer, tunable lenses with high optical quality are demonstrated [1]. Also one-dimensional beam steering is demonstrated. In both cases a reference device was fabricated without PZT layer. The benefit of using a PZT layer is obvious when comparing the PZT and non-PZT devices.

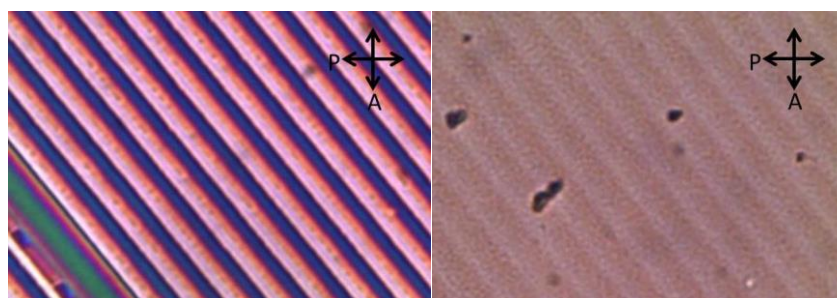


Figure 1. Liquid crystal observed under polarization microscope without PZT layer (left) and with PZT layer (right).

[1] O. Willekens, J.P. George, K. Neyts & J. Beeckman, Ferroelectric thin films with liquid crystal for gradient index applications, *Optics Express* 24, 8088-8096 (2016)