CONTROL OF LIQUID CRYSTAL ORDER BY SURFACE ELECTRIC FIELDS AND MICROSTRUCTURING

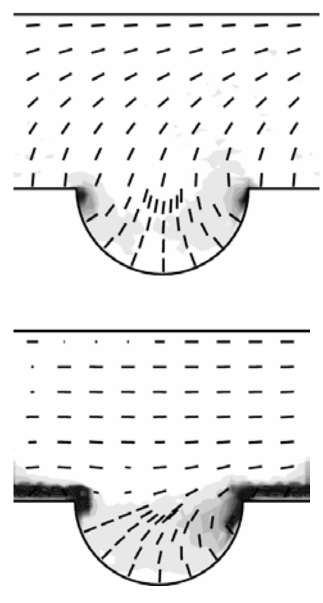
M. Kaczmarek, A. Dyadyusha, G. D'Alessandro*, G. Gilchrist, V. J. Prakash, J.J. Baumberg

School of Physics and Astronomy and School of Mathematics*

University of Southampton, Southampton SO17 1BJ, United Kingdom

email: mfk@soton.ac.uk

Optical geometries, such as 3D microscale architectures, filled with active materials can be used to tune propagation of light. In order to achieve that tailor made, micro-structured cells with optical feedback were filled with nematic liquid crystals. The cells were assembled by combining planar ITO substrates and gold-coated hemispherical micro-mirrors. Optical reflection images showed a remarkable change of symmetry in the back-reflected, polarised light when an external voltage was applied. Theoretical modelling of the alignment of the liquid crystals, confined in microstructured cells, was carried out in parallel with the experimental work. Simulations indicated that the constraints imposed by the cell geometry and by the applied electric field create conditions favouring the formation of defects. Furthermore, the motion of defects under the effect of the applied electric field was predicted and this effect can be responsible for the change of symmetry of the back-reflected light.

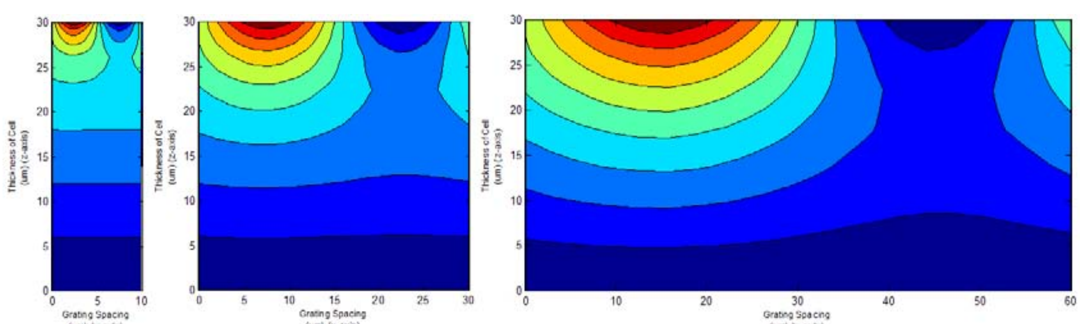


Cross-sections of simulated molecular director inside the microcavity for 0V (top) and 10V (bottom)

Surface microstructuring is not the only method for imposing selective reorientation of liquid crystals. Surface charge layers can be used for achieving strong reorientation of liquid crystal molecules in planar, photoconductive polymer-liquid crystal structures. The reorientation process in some configurations can be strongly influenced by surface-mediated effects, such as electric field, surface-charge modulation or anchoring. We studied these effects in a system where a nematic liquid crystal layer is sandwiched between two polymer layers – one photoconductive, such as poly(N-vinyl carbazole) (PVK) and one standard, such as rubbed polyimide, which serves as an aligning layer. In this system an active medium, where the change of refractive index takes place (liquid crystal) and the photoactive region (photoconductor) are separated.

The results indicate that the reorientation grating originates from the build-up and discharge of surface charge screening layers, spatially modulated due to the photoconductivity of doped PVK. The formation and subsequent discharge of surface charge screening layers can, in fact, be the main force influencing the reorientation of liquid crystal molecules.

Theoretical simulations can provide the profile and the depth of spatially modulated, electric field penetrating the liquid crystal bulk. Moreover, the maps of director distribution and refractive index can be generated to aid the optimisation of experimental parameters, such as the structure's thickness or grating spacing.



Electric field distribution inside a cell following application of a DC field and illumination with an interference pattern