Control of topological liquid crystal defects in microstructured cells

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A recently developed micro-templating technology has enabled us to generate cells with spherical mirrors with radius of curvature that spans from 100nm to 100μm [1]. This method is based on self-assembly of polyester microspheres on a gold substrate followed by electrochemical deposition of gold around them to any desired thickness. Highly reflective metallic micromirrors with selectable aperture diameters can be achieved by controlling the electrochemical deposition parameters. For the purpose of this paper we have used spheres of diameter $a = 5\,\mu$m to prepare the micromirrors with graded thickness ranging from $0.2a$ to almost a closed sphere (Figure 1).
Numerical simulations based on a Landau-de Gennes model [2] indicate that the geometry of the cell may induce the appearance of a defect (Figure 1) and that its position can be controlled by an applied electrical field (Figure 2). Measures of switching times show that the geometrical constraints force the liquid crystal defects to move much faster than they would in a planar cell (Figure 4).
To investigate the role of the defect on the propagation of light, we have illuminated the cell with a collimated beam of white, linearly polarised light, and we have measured the intensity of the back-scattered light under cross-polarisers. As the voltage applied to the cell is increased the symmetry of the reflection intensity pattern changes from four-fold to two-fold (Figure 3). We interpret this change of symmetry as due to effect that the defect has on the ray paths responsible for the four-fold intensity pattern. This hypothesis is confirmed by preliminary numerical simulations of the ray propagation in the cell.

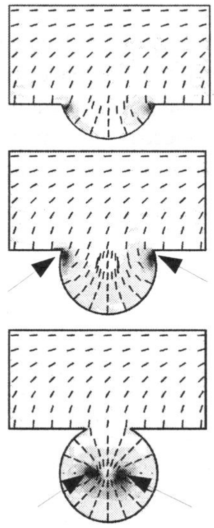

Figure 1: *The effect of geometry on liquid crystal alignment: as the spherical part of the cell closes on itself, defects appear (arrows).*

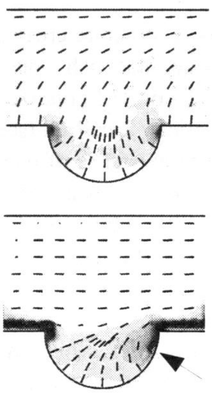

Figure 2: *The effect of an applied electric field: as the strength of the field is increased a defect appears on the side of the hemisphere (arrow).*

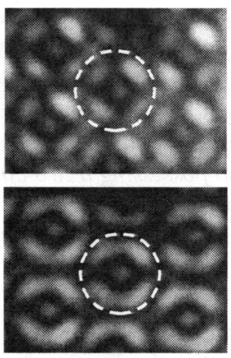

Figure 3: *Cross-polarised optical images of LC filled 5μm microdishes at 0V (top) and 5V (bottom) for 2.5μm thick Au films.*

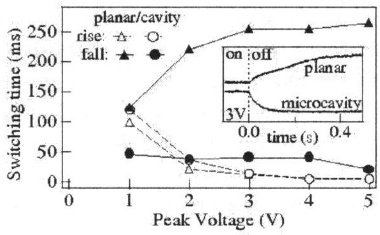

Figure 4: *Switching time as a function of the applied voltage for a hemispherical and a planar cell.*

[1] G. Vijaya Prakash, L. Besombes, T. Kelf, J. J. Baumberg, P. N. Bartlett and M. E. Abdelsalam. *Tunable resonant optical microcavities by self-assembled templating.* Opt. Lett. **29** (13), 1500–2 (2004).

[2] A. Sonnet, A. Kilian and S. Hess. *Alignement tensor versus director: Description of defects in nematic liquid crystals.* Phys. Rev. E **52** (1), 718–722 (1995).