Bistable photonic devices using organosiloxane liquid crystals

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Introduction

For many applications where power consumption is key there is a need to create high-efficiency displays which:
• are polariser-free
• require no alignment layers
• are bi- (or even multi-stable)
• simple to fabricate.
• full-colour.

Smectic A bistable device

Scattering, f < f_c (typically 100 Hz) – ‘Write’ mode

One interesting scheme is the electrically addressed Smectic A bistable device.

Clear, f > f_c (typically 1 - 2 kHz) – ‘Erase’ mode

Stable bistable device

Structure-property relations

Enhance device performance through materials optimisation

Add colour to displays via dye inclusion:

Organosiloxane materials

Smectic morphology can be enhanced through materials design. One route is the inclusion of chemical moieties which favour segregation of chemical moieties into distinct regions or sub-layers. An important class of materials which use this phenomenon are the organosiloxane liquid crystals.

Some of the main features that this class of materials possess are:
• Naturally wide temperature ranges (up to 100ºC even in the neat materials)
• Stabilisation of the Smectic phase through increased layer ordering – nematic morphology is completely suppressed.
• Highly anisotropic conductivity (up to 3 orders greater than other smectic A materials e.g. 8CB)
• Excellent bistability (textures have been stored indefinitely)

Organosiloxane materials possess a wide range of properties which make them suitable for low-power, highly efficient displays:
• Device properties tuned through materials design
• Low driving voltages through material optimisation
• Highly anisotropic conductivities
• Inherent wide temperature range greatly simplifying mixtures development

Summary and conclusions

Add colour to displays via dye inclusion:

Black absorber

Methyl red based dye

0.0 0.1 0.2 0.3 0.4
0 20 40 60 80 100
Transmission (arb.) Frequency (Hz)

0 20 40 60 80 100 0.0 0.1 0.2 0.3 0.4
Transmission (arb.) Voltage (Vrms)

0 200 400 600 800 1000 1200
Transmission (arb.) Frequency (Hz)

0 20 40 60 80 100 0.0 0.1 0.2 0.3 0.4
Transmission (arb.) Voltage (Vrms)

5/2 siloxane

∆ε = 0.8

Erase ~ 185V

Write ~ 80V

5/2 siloxane

110 100 1000 0 20 40 60 80 100
Response time (ms)

write

erase

20 40 60 80 100 0.0 0.1 0.2 0.3 0.4
Frequency (Hz) Conductivity (Ω cm)^{-1}

5/2 siloxane

Δε = 0.8

Erase ~ 185V

Write ~ 80V