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ESF Exploratory Workshop on

Frontiers in European Research on Liquid Crystalline Soft Matter

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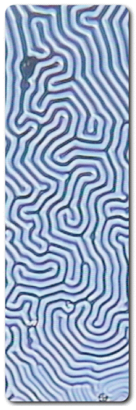

Session v. Liquid crystals in sensors, actuators and novel optic and electrooptic devices

On the balance between ferroelectric and antiferroelectric order; mono-, bi-, and tristable liquid crystals

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The surface-stabilized ferroelectric liquid crystal (SSFLC), known since 1980, is a bistable structure as it has two different stable states, with macroscopic electric polarization UP and DOWN, in absence of any applied electric field. The macroscopic polarization and bi-stability are results of the broken symmetry (from D_∞ to C_2) brought about by the surface-induced suppression of the helix of the chiral smectic C* phase. An appreciable variety of commercial devices have been developed based on these properties, for instance in the area of displays and optical processing. In both cases the very high speed of switching between the two symmetric states has been an additional asset. On the other hand, monostable antiferroelectric liquid crystals (AFLC), known since 1989, provide almost as fast electro-optic switching as the ferroelectrics, but in addition have some important advantages like analog grey scale and easy dc-compensated electronic addressing.

While nematic liquid crystals, characterized only by long-range orientational order, are relatively easy to align by treated cell surfaces, FLCs and AFLCs, which in addition have polar order as well as long-range translational order, are much more difficult to align. For instance, the anticlinic and antipolar structure of AFLCs is incompatible with any known surface condition.

By symmetry, a surface is more or less polar – and the surface states corresponding to the polarization to point into or out from the cell surface are not degenerate. When this polar anchoring is strong we can obtain monostable (twisted) structures with analog switching instead of bi-stable smectic C* structures with binary switching. Moreover, in the AFLC case, the surfaces shift the balance between ferroelectric and antiferroelectric order as the surface promotes synclinic, polar order instead of the anticlinic antipolar order of the AFLC. In thin cells, the antiferroelectric smectic C_a^* phase can be completely squeezed out by the surfaces in favor of the ferroelectric (smectic C*) state.

We demonstrate how control of surface polarity, rubbing directions, cell thickness, and liquid crystal material properties can lead to mono-, bi-, and even tri-stable liquid crystals. In the latter case we aim to use orthoconic materials, which provide extremely high contrast together with superior viewing angle, and tune the cell parameters to make the antiferroelectric ground state and the two field-induced ferroelectric states have essentially the same energy, i.e. a structure that has three stable states in absence of an applied electric field. This new structure has an interesting application potential as it combines some of the most important properties of ferroelectric and antiferroelectric liquid crystals.