DEFECTS – APPLICATIONS TO DISPLAY DEVICESTHERMAL RELAXATION RECORDING DEVICE ON SMECTIC LIQUID CRYSTALS

M. Hareng, Solenn Le Berre

► To cite this version:

M. Hareng, Solenn Le Berre. DEFECTS – APPLICATIONS TO DISPLAY DEVICESTHERMAL RELAXATION RECORDING DEVICE ON SMECTIC LIQUID CRYSTALS. Journal de Physique Colloques, 1976, 37 (C3), pp.C3-135-C3-136. 10.1051/jphyscol:1976326 . jpa-00216509

HAL Id: jpa-00216509

<https://hal.science/jpa-00216509>

Submitted on 1 Jan 1976

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

THERMAL RELAXATION RECORDING DEVICE ON SMECTIC LIQUID CRYSTALS *

M. HARENG and S. LE BERRE

THOMSON-CSF, Laboratoire Central de Recherches
Domaine de Corbeville, B. P. 10, 91401 Orsay, France

Résumé. — Nous présentons une application des mécanismes de relaxation dans les cristaux liquides smectiques A. Il est possible d'obtenir deux structures stables en phase smectique : l'une quasi homéotrope (transparente), l'autre en conique focale (diffusante). La transition s'effectue en portant le cristal liquide à une température proche de la transition smectique nématique. Cet effet est utilisé pour transférer une image sur le cristal liquide.

Abstract. — We describe here a device using a relaxation process in smectic A liquid crystals. Two stable structures can exist in the smectic A phase : one is a quasi homeotropic texture (optically transparent) and the other is a focal conic structure (scattering texture). The transition is obtained by locally heating the material to a temperature closed to the smectic nematic transition temperature. This effect is used to duplicate an image on a liquid crystal cell.

Since a few years, a lot of studies have been performed on the smectic phases and the number of possible applications increases. But, at our know ledge, the main application at this time is an I. R. laser addressed thermooptic display device [1] for the recording, storage and display of high resolution images. We describe here another class of thermooptic effects in smectic A liquid crystals for recording images.

A thin film of smectic A liquid crystal is sandwiched between two Nesa coated glasses. At rest, a thin film of SiO₂ vacuum deposited, with an oblique incidence (70°) provides a planar structure of the smectic A phase [2]. The temperature of the cell is controlled at ($T_{SN} - \Delta T$) with a good accuracy (T_{SN} is the smectic-nematic transition temperature and ΔT is 1-5 °C ranging depending upon the material). We have used in our experiments materials having :

- an high positive dielectric anisotropy,
- a nematic phase.

Then an a. c. electric field E_E is applied to the cell and gives rise to a quasi homeotropic structure in certain classes of smectic A [3] ; it is also possible to obtain the quasi homeotropic structure by cooling down slowly the material from the nematic to the smectic phase with an applied electric field.

These two structures, planar and quasi homeotropic are transparent. But, when the material is heated into the temperature range ($T_{SN} - \Delta T, T_{SN}$), one can observe, when the field is switched off, the appearance of a strongly scattering texture which is a network of focal conic domains. This scattering texture is stable within the smectic temperature range. This is a relaxa-

tion process characterized by a relaxation time which increases with $T_{SN} - \Delta T$ [4].

So, with the use of the above thermal relaxation effect, one obtains a scattering texture (for the heated points) within a transparent structure and we have demonstrated a first light valve using these two textures.

FIG. 1. — The experimental set up used to demonstrate the thermal relaxation effect.

The experimental set up is composed of (Fig. 1) :

- a low power YAG Laser ($\lambda = 1.06 \mu\text{m}$; $P = 200 \text{ mW}$),
- a shutter,
- a (beam) expander ($c \approx 16$),
- a spatial modulator (shadow mask),
- the liquid crystal cell.

(*) Supported in part by D.G.R.S.T.

A surface treatment of the substrates provides a strong absorption of the IR laser beam. We use the C. O. B. (Cyano octyl 4-4' biphenyl) which has a smectic A phase 20.5 °C-32 °C ranging and a strong dielectric anisotropy ($\epsilon_a = + 8.1$ at 28 °C). It is very easy to obtain the quasi homeotropic structure with on a. c. electric field with this material, even in the smectic phase [3]. The temperature of the cell is controlled at 28 °C (for C. O. B. $\Delta T \sim 3$ °C).

With this set up, we have succeeded to duplicate the image of the shadow mask on the liquid crystal film : the writing light (expanded laser beam) is spatially filtered by the shadow mask and the exposure time is controlled by the shutter. So, the smectic phase is locally heated of a few degrees (~ 2 °C) in order to give rise to the relaxation process. The active area of the laser beam is 20 mm diameter ; but the homogeneity of contrast and resolution is only obtained over a 10 mm diameter area. This is due to a non constant spatial distribution of the energy over all the cell.

As the change of transparency is obtained with a small increase of the temperature and without phase change, the sensitivity is better than the sensitivity of the thermo-optic effect.

This is shown in figure 2 where is plotted the ratio τ_2/τ_1 versus the power laser beam where τ_1 and τ_2 are the writing times for the thermal relaxation effect and the thermo-optic effect for the same size of point. The increase in sensitivity of our device is more important when using a low power laser beam, so with large

FIG. 2. — Ratio of the writing times : τ_2/τ_1 , for the thermal relaxation effect and the thermo-optic effect, versus the inverse of the power laser beam.

response time τ_1 . This is due to the relaxation process which is relatively slow even at temperature closed to the transition. But the writing time τ_1 has not to be very large (10 s for exemple) because the heat conductivity of the cell would decrease the resolution of the display : the intrinsic resolution of the liquid crystal is given by the size of the focal conic domains which grow from the quasi homeotropic texture. It seems that a writing time of about 1 second is a good balance between sensitivity and resolution (Fig. 3) for the cell

FIG. 3. — Microphotography of the scattering texture (storage mode) obtained by the thermal relaxation effect.

which is described above. The shadow mask on this picture is a X-Y grating the pitch of which is 600 μm . With an aperture of $f/5.6$ for the projection lens, the contrast ratio of the image of the cell is more than 15/1.

The information can be easily erased by means of an a. c. electric field at work temperature ($T_{\text{SN}} - \Delta T$).

In conclusion, a thermal relaxation effect in a smectic A liquid crystal has been used in order to demonstrate the display capacities. Our experimental set up is not suitable for practical devices, but we have shown that a high resolution, high contrast pictures can be obtained with this effect and this with a good sensitivity.

The authors would like to thank L. Thirant for her technical assistance.

References

- [1] KAHN, F. J., *Appl. Phys. Lett.* **22** (1973) 111.
- [2] URBACH, W., BOIX, M., GUYON, E., *Appl. Phys. Lett.* **25** (1974) 479.
- [3] HARENG, M., LE BERRE, S., *Appl. Phys. Lett.* **27** (1975) 575.
- [4] To be published.