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ABOUT DOMAIN WALL MOTION IN A SURFACE STABILIZED FERROELECTRIC LIQUID CRYSTAL

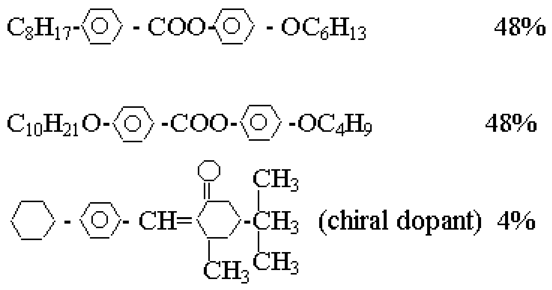
H. F. ABBASOV
Baku State University
370145, Baku, Z. Khalilov str, 23.

The domain wall motion was investigated in «the semiconductor – ferroelectric liquid crystal – metal» structure, occurring under action of an electrical field in the surface stabilized ferroelectric liquid crystal.

Due to unique properties the ferroelectric liquid crystals [1] are widely applied in engineering that, in turn, has caused wide research of these materials. Such properties are the best threshold and time characteristics of the surface stabilized ferroelectric liquid crystal (SSFLC), which strongly depend on surface conditions of electrodes, with which the liquid crystal contacts.

In the given work the domain wall motion was investigated in «the semiconductor – ferroelectric liquid crystal - metal» structure occurring under an electrical field in SSFLC.

As a liquid crystal the mixture having the ferroelectric phase in a wide temperature interval, consisting of:



and with the following phase transition temperatures:

$$C \xleftrightarrow{30^0 C} S_C \xleftrightarrow{62^0 C} S_A \xleftrightarrow{66^0 C} Ch \xleftrightarrow{70^0 C} I$$

has been used.

In structure as the semiconductor was used *p*-type Si, and as the metal electrode was used SnO_2.

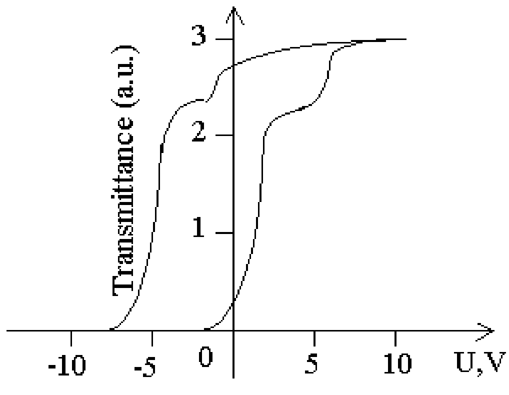


Fig.1. Light transmittance in an arbitrary units as a function of an applied voltage for the switching process under a bipolar rectangular voltage wave at the frequency $\nu = 0.01$ Hz and amplitude U_0=10 V.

To obtain a homogeneous orientation of SSFLC the surface of electrodes was preliminary treated by polyimide lacquer and subsequently rubbed in one direction [2]. It must be noted that the semiconductor essentially improves the quality of orientation. The cell thickness is about 4,8 μm, an effective area is 152mm^2. The tilt angle of molecules measured at temperature 39°C by polarizing microscope is 18°. The spontaneous polarization has been measured by the triangular pulse method [3] and at above mentioned temperature it is $0.5\,\frac{nCl}{sm^2}$.

The experiment was carried out in the set up on the basis of polarizing microscope. The light transmittance of the cell was measured by the photo multiplier, the signal from which was registrated by the oscilloscope. Under an electrical field action the Clark-Lagerwall transition takes place [4]. As well as known, the electrooptic effect occurs in two stages: at first at low voltage the bulk switching (I) takes place, and then at high voltage the surface switching – the domain wall motion (II) takes place (fig.1). From this oscillograms, which are received at different values of the applied voltage, the switching time was determined (fig. 2).

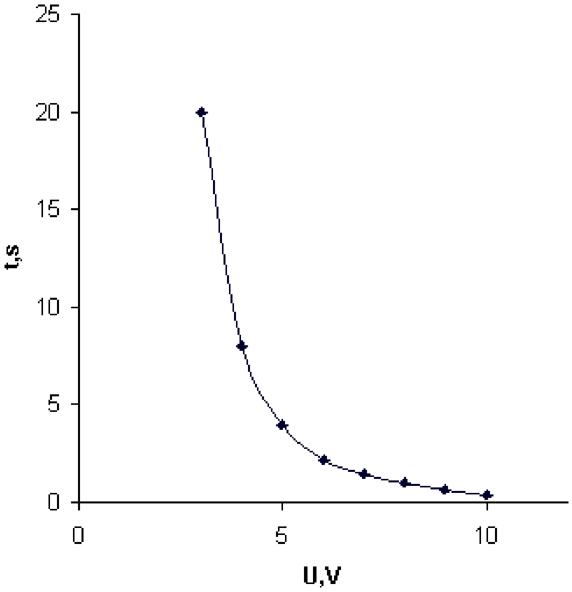


Fig.2. The dependence of the switching time on the applied voltage.

As seen from figure 2, the switching time decreases with increasing of the applied voltage. By drawing this dependence in logarithmic scale we have established, that the dependence $\tau(U)$ has the form $\tau \sim U^{-2}$

In order to explain the obtained results, we propose the following model. Let S_0 is an effective area, where we observe the domain wall motion, $n(t)$ is a number of domains in this area and $S(t)$ is the area which is occupied by domains at the given moment, dS is the increment of the area of all domains. It is clearly that dS is proportional to the domains' free area $(S_0\text{-}S)$, to the total increment of the all domains area ndS' and inversely proportional to the already occupied by domains area S, i.e.

$$dS = c\frac{S_0 - S}{S}ndS' \qquad (1)$$

where C is a coefficient of proportionality.

Let's take into account, that the area increment of the domain having the circular form of radius r looks as

$$dS' = 2\pi r dr = 2\pi\overline{\upsilon}t\cdot\overline{\upsilon}dt = 2\pi\overline{\upsilon}^2 tdt$$

The domain wall velocity depends on a direction. Therefore the averaged domain wall velocity determined as $\overline{\upsilon} = \sqrt{\upsilon_{\|}\cdot\upsilon_{\perp}}$ is used at the calculations, where the signs $\|$ and $\perp$ belong to the case of motion in the direction parallel and perpendicular to the smectic layers, accordingly.

It is obviously also, that the number of domains is inversely proportional to the time, as they covered each other: $n \approx \frac{c'}{t}$. After the integrating of (1) we obtain:

$$\int_0^S \frac{S}{S_0 - S}dS = \int_0^t 2\pi\overline{\upsilon}^2\cancel{t}\cdot\frac{C'}{\cancel{t}}dt \qquad (2)$$

$$ln\left(1-\frac{S}{S_0}\right)+\frac{S}{S_0} = -\frac{2\pi C'\overline{\upsilon}^2 t}{S_0} \qquad (3)$$

where, $C'=c\cdot c'$.

The expanding of the expression $ln\left(1-\frac{S}{S_0}\right)$ in a series at $S=0$ and neglecting of the high order members gives:

$$\frac{S_0}{2}\left(\frac{S}{S_0}\right)^2 = 2\pi C'\overline{\upsilon}^2 t \qquad (4)$$

At complete switching, when the domains occupy all effective area, i.e. $S=S_0$ and $t=\tau$, we obtain

$$\tau = \frac{S_0}{4\pi C'}\cdot\frac{1}{\overline{\upsilon}^2} \qquad (5)$$

The theoretically predicted dependence of the domain wall velocity on the applied voltage U is linear [5-7]:

$$\overline{\upsilon} = \frac{2P}{\eta N}U \qquad (6)$$

where, P is the spontaneous polarization, η is the rotational viscosity, N is the parameter that describe the surface.

Then we obtain the following expression for switching time

$$\tau = C\frac{\eta^2}{U^2} \qquad (7)$$

where, $C = \frac{S_0 N^2}{16\pi C'}$ is a coefficient which depends on the surface state.

Thus, the proposed model correctly explains the dependence $\tau(U)$ obtained experimentally.

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H.F. Abbasov

SƏTHLƏ STABİLLƏŞMİŞ SEQNETOELEKTRİK MAYE KRİSTALDA DOMEN SƏRHƏDLƏRİNİN HƏRƏKƏTİ HAQQINDA

«Yarımkeçirici-seqnetoelektrik maye kristal-metal» strukturunda səthlə stabilləşmiş seqnetoelektrik maye kristalda elektrik sahəsinin təsiri altında Klark-Lagervol effekti baş verdikdə muşahidə olunan domen sərhədlərinin hərəkəti öyrənilmişdir.

Х.Ф. Аббасов

О ДВИЖЕНИИ ДОМЕННЫХ ГРАНИЦ В ПОВЕРХНОСТНО СТАБИЛИЗИРОВАННОМ СЕГНЕТОЭЛЕКТРИЧЕСКОМ ЖИДКОМ КРИСТАЛЛЕ

В работе было изучено движение доменных границ в структуре «полупроводник-сегнетоэлектрический жидкий кристал-метал», происходящее под действием электрического поля в поверхностно стабилизированном состоянии сегнетоэлектрического жидкого кристалла при осуществлении в нем эффекта Кларка-Лагервола.

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