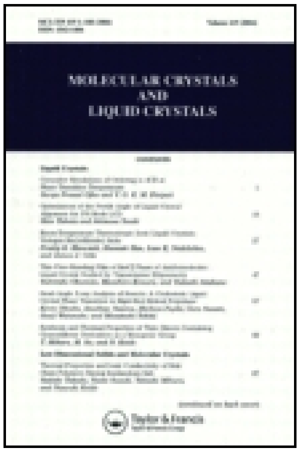

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SURFACE ANCHORING INFLUENCE ON POLARIZATION SWITCHING PROPERTIES OF SSFLCS

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AND T. YOSHIHARA

Abstruct
Polarization switching properties of SSFLCs in terms of the surface anchoring effect were investigated. Low frequency and low voltage triangular waveform applications on to low, medium and high pretilt cells suggest that the low pretilt chevron geometry cell provides stronger anchoring effect. Low pretilt quasi-bookshelf cell indicates whole LC molecule's switchings including the interface area. This conclusion is also supported by the polarization switching study under the compression and expansion environment.

INTRODUCTION

Polarization switching behavior is one of the most important phenomena to understand the electrooptical characteristics of the surface stabilized ferroelectric liquid crystal (SSFLC) display device. In the surface stabilized geometry, it is assumed that the polarization switching is affected by the surface anchoring effect. We tried to understand the surface anchoring influence on polarization switching properties of the SSFLCs. We looked into the pretilt angle of the liquid crystal at the surface and the smectic layer structure. The high pressure study of the polarization switchings[1,2] is also suggestive for our purpose. We also investigated the polarization switching behavior under the compressive and expansive environment.

EXPERIMENTAL

For our purpose, we prepared three types of chevron layer structure cells with low, medium and high pretilt. We chose particular polyimides which gave rise to less than 2 degrees of low pretilt to nematic liquid crystals, 4 degrees of medium pretilt and more than 8 degrees of high pretilt, respectively. We also prepared a quasi-bookshelf layer structure cell with a low pretilt using the naphthalene-base FLC.[3]

The polarization switching behavior was investigated by the switching peak current. The compressive and expansive environments were given to the FLC cell by using the set-ups shown in Fig. 1.

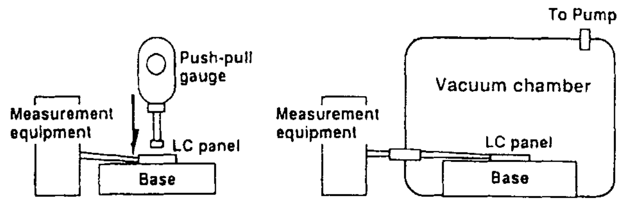

Figure 1 The set-up of the compressive and expansive measurement.

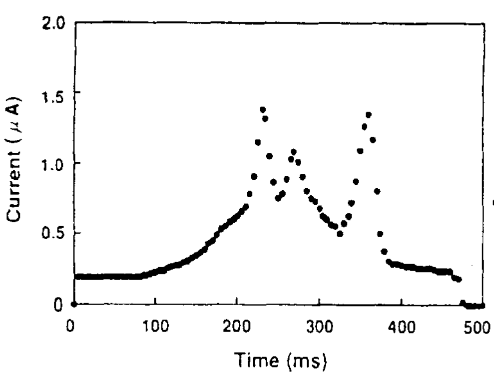

Figure 2 The polarization switching peak current of the low pretilt chevron layer cell.

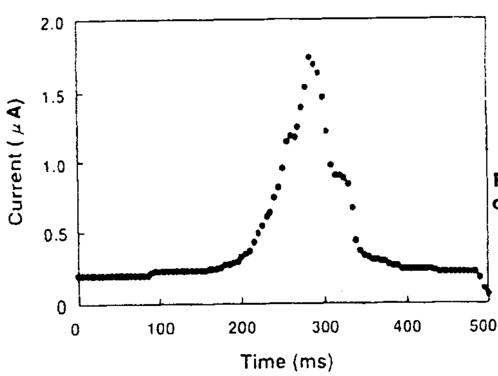

Figure 3 The polarization switching peak current of the medium pretilt chevron cell.

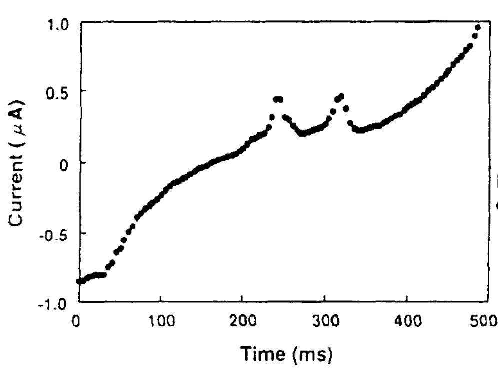

Figure 4 The polarization switching peak current of the high pretilt chevron cell.

RESULTS AND DISCUSSIONS

1. Polarization switching behavior on the pretilt

The low pretilt chevron layer cell showed three polarization switching current peaks as shown in Fig. 2. The three peaks contain two rather sharp peaks and one broad peak. The medium pretilt chevron layer cell exhibited one large peak and two small peaks as shown in Fig. 3. The high pretilt cell presented two peaks which were almost equal size as shown in Fig. 4. In Fig. 4, the base line of the switching current inclines. This inclination is interpreted as an ionic conduction effect. The chevron layer geometry is clasified to four types of polarization structures : C1U, C1T, C2U and C2T in terms of the alignment of the molecular long axis.[4] We observed both of C1 and C2 domains in the low pretilt cell. In the medium pretilt cell, both of C1 and C2 domains are observed, however, C2 domains are dominant. The high pretilt cell showed C2 uniform alignment. The difference in the polarization switching currents observed in Figs. 2, 3, 4 is provided by the difference in the polarization structure. The difference in the polarization structure should be come from the pretilt angle at the surface. The three distinct peaks shown in Fig. 2 are interpreted by the following two reasons. One is a time lag of polarization switchings between C1 and C2 domains. The other is a time difference of polarization switchings along the liquid crystal thickness direction. The existence of C1 and C2 domainds explains two split peaks in Fig. 2. Three distinct peaks observed in Fig.2, however, should have another reason. Although three peaks are not so distinct that is observed in the low pretilt cell, the medium pretilt cell in which C2 domain is dominant also shows three peaks. Thus, the observed split peaks suggest that there are easy switching and difficult switching portions in the thickness direction. This is supported by the two distinct peaks in the high pretilt cell which shows a C2 uniform alignment. The high pretilt cell shows a clean molecular alignment under the observation of the microscope. The polarization switching of the cell is almost uniform.

Those split peaks can be observed only when both the voltage and frequency of the triangular waveform are low enough such as ± 5 V, 1 Hz. Figure 6 shows the result of the quasi-bookshelf layer cell. Unlike the chevron cells, the quasi-bookshelf cell exhibits a sharp single peak as shown in Fig. 5. This single peak suggests that the polarization switching of the quasi-bookshelf cell is uniform both in terms of the plane and the thickness directions.

2. Spontaneous polarization dependent on the pretilt

We supposed that if the polarization structure has some varitey in its thickness direction, carefull observation of the polarization switching current dependent on the applied voltage should present some differences. Figures 6 and 7 show the applied voltage dependence of the spontaneous polarization :Ps of the low pretilt chevron cell and the quasi-bookshelf cell, respectively. In the low pretilt cell, Ps is led by each peak, respectively. These results indicate that both the chevron and the quasi-bookshelf cells accept some suppression in the polarization switching behavior. The quasi-bookshelf cell, however, shows a constant Ps above 5 volts application region so that the polarization suppression effect is very small in the cell. In contrast, Ps of the low pretilt chevron cell corresponding to each peak, shows a strong dependence of the applied voltage. The difference of Ps dependence of the applied voltage suggests that the quasi-bookshelf cell causes a full body switching while the low pretilt chevron cell shows a partial switching. The suppressed polarization portion in the

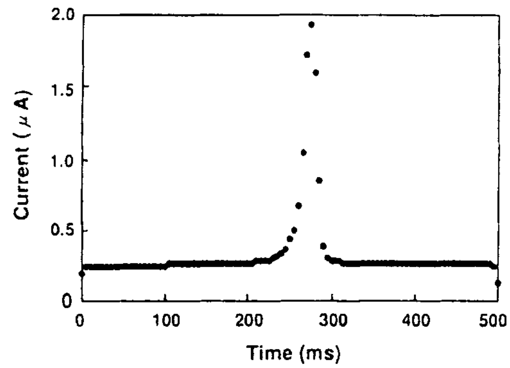

Figure 5 The polarization switching peak current of the quasi-bookshelf layer cell.

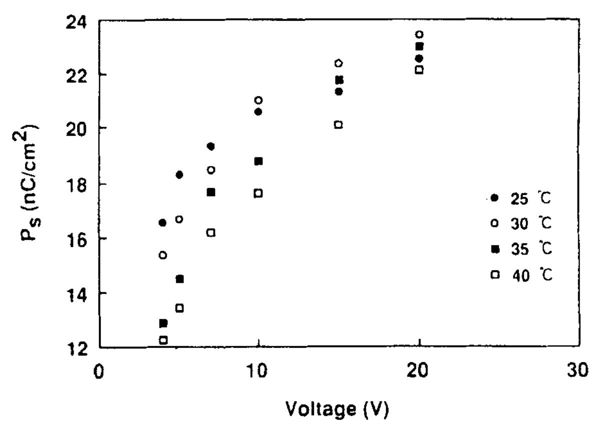

Figure 6 The suppression of the polarization switching in the low pretilt chevron layer cell.

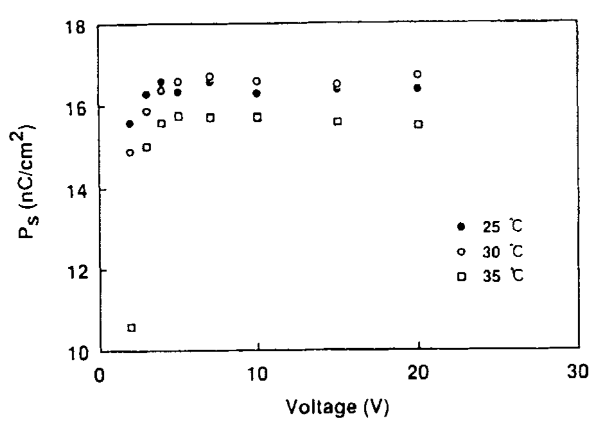

Figure 7 Applied voltage dependence of the spontaneous polarization in the quasi-bookshelf layer cell.

low pretilt chevron cell is assumed to be the surface anchoring area or the kink area where two bend smectic layers meet together.

3. Polarization switching behavior under the compressive environment

The influence of surface anchoring effect on the polarization switching behavior should be dependent on the compressive and expansive environments. Unlike the nematic device, the smectic device which has a layer structure is vulnerable to the suppression of the layer. The suppression of the layer structure particularly the suppression along with the cell gap direction in the SSFLC brings about the disorder of liquid crystal alignment. In the process of the disorder of liquid crystal molecular alignment, the surface anchoring effect is assumed to take an important role in terms of the easiness of liquid crystal layer movement at the interface between the liquid crystal molecules and the alignment layer. We looked into the pretilt of the alignment layer as one of the main parameters of the surface anchoring effect. We tried to understand the polarization switching behavior under the compressive and expansive environment by changing the pretilt of the alignment layer and the layer structures: the quasi-bookshelf and the chevron. The compressive and expansive environment influence on the spontaneous polarization: Ps is shown in Fig. 8 for each pretilt chevron layer cell. Figure 8 suggests that the molecular alignment against the pressure is strongly dependent on the pretilt at the interface. It is obvious that the low pretilt chevron cell is very sensitive to the external pressure. The medium pretilt chevron cell is rather insensitive to the external pressure. The increase of Ps with the increase of the external pressure shown in the high pretilt chevron cell is interpreted by the calculation method of Ps. The high pretilt cell shows a distinct ion current as shown in Fig. 4. The separation between the two peaks of polarization switching currents becomes difficult as the increase of the external pressure. The two peaks come closer with the increase of the external pressure, resulting in the overestimation of Ps. The pressure sensitivity of spontaneous polarization in each pretilt cell shown in Fig. 8 indicates that the low pretilt chevron cell provides the strongest surface anchoring effect among the three chevron cells.

Figure 9 shows the pressure influence on Ps of the quasi-bookshelf cell. This cell presents two types of pressure dependence of Ps. The Ps measured after removing the pressure shows a stronger influence on Ps than the Ps measured under the pressure. These results shown in Fig. 9 suggest that the surface anchoring effect on the polarization switching behavior is small in the quasi-bookshelf cell. Under the pressed condition even though the liquid crystal layer is suppressed, a free surface allows the liquid crystals at the surface to rearrange the molecular alignment in some extent. Thus, the quasi-bookshelf cell affects a rather small influence of compressive environment to the polarization switching behavior.

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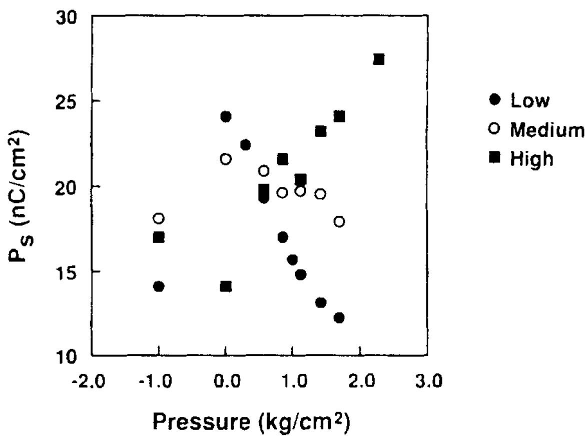

Figure 8 The polarization switching phenomena under the compressive and expansive environments of the chevron layer cell.

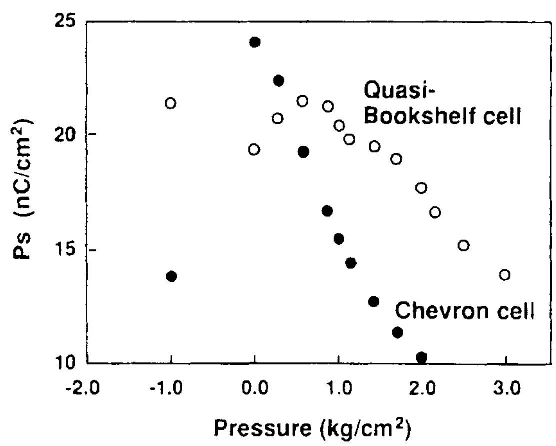

Figure 9 The influence of the layer structure on the polarization switching behavior in the compressive and expansive environment.