

The Study of the Charge Transport on the Surface Layer of the Patterned Vertical Alignment(PVA) Mode

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Keywords : Ion impurity, Image sticking, Charge transport

Abstract

It is known that the main source of the area image sticking is the ion charge adsorption on the alignment layer. We found out that the adsorption of the ion charge of the liquid crystal in the cell was physisorption, which takes place between all molecules on any surface providing the adsorption force is small.

1. Introduction

It is well known that there are two kinds of types in the adsorption of charges that are physisorption and chemisorption. The former is weak bonding between a surface and charges. It is reversible reaction. The other hand, the latter is strong bonding and irreversible. Enthalpy energy is usually used to find bonding energy. The force that makes ions to a surface is residual DC voltage that is caused from the asymmetric AC driving voltage of LCD. It is suspected to form electric double layer in an LC cell through adsorption process.

In this paper, we estimated the bonding energy of ions on electrode by calculating the Arrhenius equation at various temperatures. Also we measured it on the different types of alignment layer cells and different cell gaps. Through this, we found the type of adsorption of charges in a liquid crystal cell and the relationship between the adsorption/desorption activation energy of ions and parameter of cell conditions.

These experiments may help us to understand image sticking caused by ion transport because of residual DC.

2. Experimental

To measure a capacitance as time, we prepared a PVA cell which cell gap was 4 μm . LC material was negative liquid crystal (Merck Corp. $\Delta \epsilon = -3.8$). Alignment Materials were polyimide type (type A) and polyamic acid (type B) (JSR Corp.) and we measured residual DC as time in Figure 1. As shown in Figure 1, Residual DC value as time decreased because charges on the surface were decreased by the diffusion of ion impurities. To measure residual DC, we applied dc voltage (+9V) to the cell for 1 hour. After that, floated the cell for a second and we shorted the cell. Then we started to measure the residual DC of the cell by using the multimeter. This method is the conventional residual DC measurement.

3. Results and discussion

Residual DC measurement of the test cells was evaluated at 25 °C, 35 °C and 50 °C.

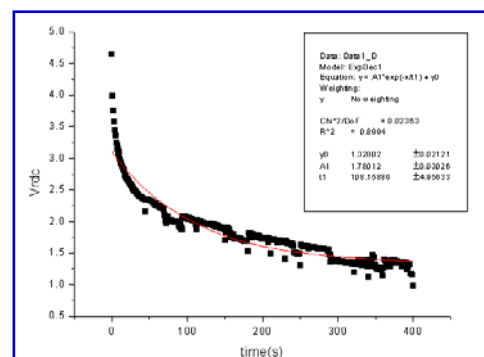


Fig. 1. Residual DC vs. time

we derived the Arrhenius activation energy of the adsorption of the ions on the substrate.

The process of getting the activation energy is bellow.

Equations are placed in center and should be preceded and followed by one line of white.

$$-\frac{dC}{dt} = kC \quad (1)$$

$$\therefore C = C_0 \exp(-k_d t) \quad (2)$$

Eq 1. is the reaction velocity equation. C is the charge density as time. Co is the initial charge density of the cell.

We could estimate the residual DC through the charge density since the higher charge density, the higher residual DC.

$$\therefore V = V_0 \exp(-t / \tau) \quad (3)$$

τ is the relaxation time that is the inverse of the desorption reaction constant.

Arrhenius equation is bellow.

$$\frac{\ln \tau}{1/T} = -\frac{\Delta H_a}{R} \quad (4)$$

T is absolute temperature, ΔH_a is adsorption enthalpy energy and R is gas constant ($R=8.31 \times 10^7$ erg/mol-K)

Using the Eq. 4, we could get the adsorption enthalpy energy of the cell.

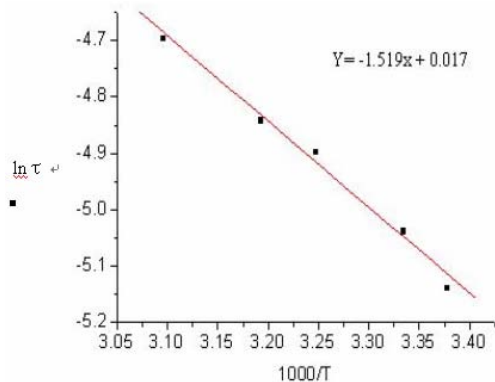


Fig. 1. $\ln \tau$ vs. $1000/T$ graph

Fig. 2 is Arrhenius plot data that was gained from log

value of rate constant as temperature. We could calculate activation energy value by Eq. 4.

By changing the experiment conditions that were alignment layer type, the depth of the alignment and cell gap, we could get the below results.

PI type	PI depth(Å)	cell gap(μm)	$\Delta H(\text{kJ/mol l})$
A - TYPE	1500	2.1	18.22
B - TYPE	1500	3	28.43
B - TYPE	1500	1.99	12.41
A - TYPE	2700	2.4	16.1
B - TYPE	3900	2.3	47.96
B - TYPE	3900	8.2	49.8
B - TYPE	3900	4.8	58.95

TABLE 1. The results the adsorption energy by the various conditions

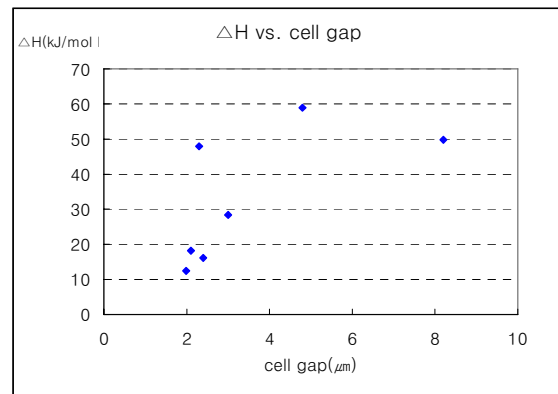


Fig. 3. Adsorption enthalpy energy vs. cell gap

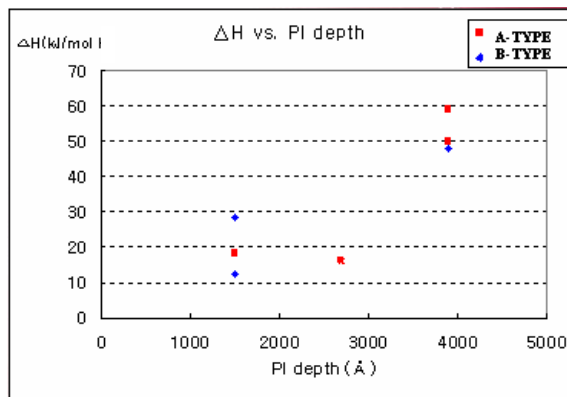


Fig. 4. Adsorption enthalpy energy vs. PI depth

In the Figure 3, we could know that the higher cell

gap of the cell, the higher enthalpy energy. Figure 4 indicated the thicker alignment, the higher enthalpy energy.

Through these results, we could know that the adsorption of enthalpy energy of the ion charges was affected to cell gap and PI thickness.

It is well known that when the range of adsorption energy is from 50kJ/mol to 500kJ/mol, the adsorption is called 'Chemisorption' and when it is from 5kJ/mol to 50kJ/mol, it is called 'Physisorption'. In the case of Physisorption, the strength of the bonding between molecules and substrate is weak and the reaction of the adsorption and desorption is reversible. In our measurements of the adsorption enthalpy, we could find out that the ion transport on the alignment layer is associated closely with Physisorption.

4. Summary

If same image is displayed on the LCD TV for long times, the image would remain on the TV for some time when you change the image. It is big problem that is called 'Image sticking'. The reasons of the image sticking are various. Among them the ion impurities of the cell may be the main factor. In particular, it is very important to know what happens on the boundary between liquid crystal and alignment layer.

In this paper, we evaluated the adsorption enthalpy energy on the alignment layer at various temperatures and could found out that the ion adsorption of the liquid crystal is Physisorption reaction. Through this experiment, we could understand the image sticking of the liquid crystal

5. References

1. J.Y. You and J.J. Jung, N.C. Choi, K.W. Rhie and S.T. Shin, *SID'07 Technical Digest*, P-205, p673 (2007).
2. Herbert de Vleeschouwer, Bart Verweire, Koen Dhavé and Hua Zhang, *Mol. Cryst. Liq. Cryst.*, Vol. **331**, p567 (1999).
3. Moldovan R, Frunza S, Beica T, and Tintaru M., *Liquid Crystals*, Vol. 20, p331(1996)
4. H.Seiberle and M.Schadt, *Mol. Cryst. Liq. Cryst.*, Vol. **2391**, p2297 (1994).
5. Po-Lun Chen, Shu-Hsia Chen, *Liq. Cryst.*, Vol. **27**, p965 (2000).